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CONTENTS

LEADING ARTICLES—
A Tradition Abandoned 137
"We've Just Gotta Get Used to It!" ... 138

ARTICLES—
André Chapelon and the Steam Locomotive 140
Boiler-Transporting Trailer. (Illus.) ... 162
Burning Colliery Slurry... 163
Centrifugal Self-Priming Pumps. (Illus.) 161
Combined Pulverised Coal and Oil Fuel Firing for Power Stations. (Illus.) 158
Computer-Controlled Machine Tools... 151
Diesel-Electric Locomotives for Eire. (Illus.) 162
Expressions for Circular Section Bow Girders Carrying Concentrated Loads. (Illus.) 145
Extensions at the Works of the Power-Gas Corporation, Ltd. (Illus.) ... 147
Flame Hardening of Crankshafts. (Illus.) 160
Geophysical Prospecting. No. II. (Illus.) 143
High-Speed Mobile Cranes. (Illus.) ... 163
Indian Electrical Industry 165
Installation of Repeaters in London/Gibraltar Submarine Telegraph Cable 139
Kitimat-Kemano Power Transmission Line Carrier System. (Illus.) ... 161
Launch of the Liner "Bergensfjord"... 139
National Coal Board Report for 1954... 139
Oil Burning at C.E.A. Power Stations... 139
Powered Steering on 7-ton Truck... ... 165
Proposal for a National Highway Authority... 139
Road Improvement in Birmingham 139
Self-Gripping Work Driver. (Illus.) ... 163
Six-Spindle Bar and Chucking Automatics. (Illus.) 164
Small Centreless Grinder. (Illus.) ... 160
Tractable Marine Boiler... 161
Two Modern Foundries. (Illus.)... ... 164
Valve to Limit Braking Effort. (Illus.) 162
Wire Twisting Tool. (Illus.)... 159
Wobbe Index Indicator. (Illus.)... ... 159
100W A.C./D.C. Vibrator 165

AMERICAN SECTION—
Folsom Dam in California. (Illus.) ... 168
Hot Wire Anemometer Measurements in Supersonic Flow. (Illus.)... ... 169
Nuclear Congress and Atomic Exposition 169

METALLURGICAL TOPICS—
Mechanical Twinning and Fracture. (Illus.) 156
Factors Affecting the Ductility of Chromium 157
Effect of Rare Metals on Steel. (Illus.) 157
Comparison of Schnadt and Charpy Impact Test Pieces. (Illus.) 157

LETTERS AND LITERATURE 154
LETTERS TO THE EDITOR—
Coal and the National Fuel Policy... 154
"Gas Turbine Series." Vol. I. ... 154

LITERATURE—
Book Reviews... 155
Short Notices 155
Books Received 155

NEWS AND NOTES—
British Patent Specifications. (Illus.)... 171
British Standards Institution... 172
Catalogues 172
Continental Engineering News 166
Forthcoming Engagements 172
Industrial and Labour Notes... 167
Personal and Business 170

A TRADITION ABANDONED

For very nearly a century the arrangement of articles in this journal has been basically the same. Changes there have certainly been. The sizes of types used have, for example, been progressively increased, larger and more showy headings have been assigned to the more important articles, not so long ago column rules disappeared. But throughout all these years the leading articles have appeared on the centre opening of each issue and the more important other articles have been printed at the front of the editorial pages. That "make-up," to use for it a printer's term, has persisted into our 200th volume in spite of the fact that more recently founded journals, more particularly within this century, have chosen to adopt a different style in which the leaders appear on the opening pages. With this issue, it will be observed, we fall into line with them.

We do so with some regret. A journal that is almost one hundred years old naturally has a high respect for tradition; and we have fraternal feelings for other journals when we observe that they too have their leaders on their central pages. For that positioning of the articles in which the Editor expresses his opinions signifies that those journals, too, are old established; and when they were founded there was a good reason for placing the editorials in that position. When THE ENGINEER was established in 1856 its format was very similar to that of the daily papers of its day, not dissimilar, indeed, from the format that *The Times* still retains. The pages were larger than they now are and there were many fewer of them. They were not even stapled together, so that, as with the daily and evening papers of to-day, they could be folded this way or that to facilitate reading in a train or in cramped quarters. It was natural and desirable to follow the custom of the day. With the passage of time, however, the numbers, both of editorial and advertising pages, grew, so that for convenience it became necessary to staple the pages together and thus make a "saddle-back" volume. When, however, more recently founded journals came into being they considered, from the start, that there was no necessity to adopt so large a page. For few had to contend as frequently as THE ENGINEER with the reproduction of large and complex drawings. Instead they adopted a format then becoming common amongst more popular magazines. Pages were smaller and more numerous and the arrangement more like that of a book. It naturally followed that the leading articles were placed, with the index, at the front. But the fact that more recently established journals adopted a different make-up was considered neither by THE ENGINEER nor by other old established journals a sufficient reason for changing theirs. For, in fact, upon examining the situation our Editor (and no doubt theirs) could see no such sufficient advantage in the new arrangement as to compel a change; and if there is no disadvantage in hanging on to a tradition why not hang on to it? It could even be argued that there was a positive benefit in so doing. For so long as the saddle-back binding is retained those editorial pages that are most easily found are just the centre pages on which the leaders are printed. Each issue opens naturally and easily at its centre. Thus, though perhaps librarians may have felt some irritation because indices were not in some standardised position in all the technical journals they received, it could still be maintained that so long as these indices were on the central opening they were, in fact, more easily found than in journals that had adopted a more modern make-up!

But alas for tradition! We can no longer use the argument. There are limits to the use that can be made of saddle-back stitching. A reduction in the page size of THE ENGINEER enforced by wartime paper shortage has resulted in an increase in the number of editorial pages. Larger type sizes have similarly

tended to increase the number of editorial pages. Above all a big increase in the popularity of this journal as an advertising medium has so thickened up each week's issue that the limits of saddle-back stitching were long since reached if not indeed exceeded. To the great offence of the Editor whose job it is to see that leading articles appear each week, he has observed often in the last few months a deplorable tendency for the leader pages to tear themselves out of the issue! We fear that tendency may have been even more pronounced in issues which, in accordance with the practice of many firms, are circulated through many hands before reaching a reference place in the firm's library. Moreover, the external appearance of each issue was becoming unsightly as the staples, forcing their way through so many sheets of paper, bit deep into and tore the back of the cover. The decision was taken therefore to change to square-back binding. With that decision has gone—alas!—all remaining justification for retaining a make-up with leaders on the central opening, an opening indeed, which no longer exists as something unique in each issue, since with square-back binding each sheet on which matter is printed, is folded and laid atop of the other sheets instead of being wrapped round them as with saddle-stitch. In short we have not been able to resist the modern trend. Henceforth the opening editorial pages of each issue will contain the leaders. Yet we retain our respect for tradition. It has not been quite wholly abandoned. If readers are to find their way about in a journal that presents to them weekly between 32 and 36 pages of editorial matter, and may in future present even more, there must be some orderly arrangement. Articles cannot follow one another higgledy-piggledy to accord merely with the Editor's or the printers' convenience. We intend that articles of similar character shall invariably occupy similar positions in each issue; and in order to help readers to comprehend the new arrangement we shall place each week, near the centre, two pages headed "Letters and Literature" under which letters to the Editor and book reviews will be printed. This will take the place of the traditional leader opening and serve to break up the editorial pages between the front and back of each issue. Furthermore the page entitled Industrial and Labour which formerly appeared near the end of each issue is now brought forward to make a break before our American Section opens. In coming weeks we, like our readers, will be unfamiliar with our new make-up. We ask their indulgence if for a little while we prove to be experimental in choosing the position that articles of various characters will occupy. We should much value any comments they care to make.

"WE'VE JUST GOTTA GET USED TO IT!"

During the war there was for a short while popular a humorous song about Army service whose chorus ran "You've just gotta get used to it!" A new verse to that song might well be now written about the coal shortage in this country. We have "just gotta get used" to the fact that never again will this country become a great exporter of coal, and never again will there be in this country super-abundant supplies of cheap fuel. It was natural enough immediately following the war to assume that within a short span of years the pre-war condition would reassert itself, that output could be built up and that a substantial excess of coal production over and above home needs would permit exports to be resumed upon a large scale. It was natural, too, to enter into commitments, even if only of a token character, to export coal, so that contact could be regained with pre-war markets. But now, ten years later, the true position has been more clearly revealed. Coal output has been static over the last three years at slightly less than 225 million tons a year; the home demand continues to grow; and even if the Coal Board does manage to reach, within the next decade, the target figure of 240 million tons a year mentioned in the Coal Plan, it is still improbable that output will be sufficiently high to meet all home demands, let alone provide an excess for export. "We've just gotta get used to it!" To import coal expensively from America to replace coal exported to the Continent does not make sense.

There is no tragedy for the country in this change. It is not a disaster. For to employ men to work up raw materials into finished products must surely be at least as profitable as employing them to fetch the raw materials out of the ground. Post-war experience has shown how a great expansion of engineering exports can replace the pre-war coal exports, and the potentialities for expanding engineering exports are surely far higher than those of expanding coal exports could ever become! Nor, in the longer run, do we believe that less abundant supplies of home fuel will do very much harm to industry in this country, however disturbing the situation may temporarily seem while adjustments are made to meet the new circumstances. Ever since the Industrial Revolution coal has been so abundant in this country—in contrast to the experience of others—that there has been little or no incentive to use it economically. In the past fuel costs within the engineering and many other industries have amounted to an almost negligible fraction of total costs, perhaps about 2 per cent. As coal was so cheap and plentiful it was not worth while incurring capital expenditure on efficient fuel-using plant or employing the services of specially trained stokers. It was cheaper to accept wasteful usage of coal in order to avoid the costs of servicing and maintaining capital equipment and paying the higher wages that a skilled stoker would demand! Nor was there any profit to be found in effectively insulating pipes and buildings since the capital charges and maintenance costs outbalanced the cost of the fuel wasted. Now, as fuel prices rise managements need to examine with more care what can be done to economise in fuel usage. There is no lack of scope. As a correspondent in this issue emphasises, it is a finding of Sir Leslie Hollinghurst, chairman of the National Industrial Fuel Efficiency Service, that there are few factories in general industry in which fuel consumption could not be cut by 15 to 20 per cent. Our correspondent summarises, too, how economies can be brought about, by employing fully trained stokers for hand-fired boilers and using mechanical stokers even for relatively small plants, by an extended use of back-pressure generating sets wherever process steam is needed, by the utilisation of waste heat from diesel plants, by the efficient insulation of pipework and buildings and by waste heat recovery wherever possible. But these routes to keeping fuel costs down, despite increased fuel prices, are not open to certain industries, notably shipping, iron and steel, and electricity generation, in which fuel costs amount to a substantial fraction of total costs and in which, in consequence, efficiency in fuel usage has long been sought. Steel prices have already been raised. Yet British steel prices still remain substantially below those ruling on the Continent.

Far from seeking any scapegoat for the recent rise in the cost of coal the engineering industry, we feel, should accept the new situation of possibly perpetual fuel shortage as a challenge to its ingenuity. An increase in coal prices had become inevitable, and if the general level of wages in industry continues to rise, further increases in price may well follow, as miners' wages also rise. For it is already difficult to attract sufficient manpower to the mines. We hold no brief for nationalised industries. We see no particular virtues in public ownership. But one thing does seem to have become clear from the experiences of the Coal Board and the Transport Commission. Monopolies must invariably be suspected of holding prices too high, to their own advantage; but not those under public ownership! They, operating in the full glare of publicity, their policies open to question and debate in Parliament—as occurred last week—many of their actions having to be taken after consultation with the Government, can never press prices far above costs. Rather is it likely that they will be kept too low. We find it very difficult to believe that, were the coal industry in

private hands, coal prices would be any lower than they have just become. In short, industry, despite the disruption wrought by the need to adjust to new circumstances has "just gotta get used to it!" Nor will there be a lack of benefit once adjustment has been made. More efficient fuel usage means less smoke and cleaner air. Higher prices for fuel may result, in the longer run, in lower costs of production because the costs of upkeep of buildings will fall, the people will be in better health, and there will be a higher return for agriculture.

A Seven Day Journal

National Coal Board Report for 1954

IN the House of Commons last week, Mr. Geoffrey Lloyd, in introducing the National Coal Board report and accounts for 1954, characterised the rise in the price of coal as a strong inducement to economise and commented on the work of the National Industrial Fuel Efficiency Service, which had resulted in the saving of 1,000,000 tons of coal. Falling coal production and increased industrial demands, he continued, had created a position which meant a sharp reduction in our exports in 1956 from the present level of 13,000,000 tons. The industry was embarked on a policy of renewal and a figure of 21,000 men was mentioned as representing the number engaged on development work. The Minister referred to the manpower problem and after stating that coal cutting was 85 per cent mechanised and transport through the pit 90 per cent mechanised, he commented that 90 per cent of the coal was still loaded by hand and that represented the labour of 80,000 workers. A scheme for increasing the tonnage of power-loaded coal was in hand and was expected to replace men at the rate of 5000 per year. Some savings were in prospect by the use of oil by the Central Electricity Authority, and by 1960 it was expected that oil would replace about 9,000,000 tons of coal. A further 1,000,000 tons might be expected to be saved by the gas industry making gas from oil, and mention was made of the general change over to oil for steam raising. In all, Mr. Lloyd stated, the oil industry was expected to be supplying oil to industry to an amount equal to 25,000,000 tons of coal. It was expected that by 1960 the atomic energy programme would be in a position to make a substantial contribution to the country's power requirements.

Oil Burning at C.E.A. Power Stations

LAST week an agreement was made between the Central Electricity Authority and Shell Mex and B.P., Ltd., for the supply of oil fuel to seven of the Authority's power stations—Ince, Bromborough, Cliff Quay (Ipswich), Carrington (Manchester), South Denes (Great Yarmouth), Belvedere, and a projected new station on the Thames estuary. In addition, the Bankside "B" power station, which is already supplied with fuel oil by the company, is now included in this agreement. Initially, the agreement is for twelve years, with a maximum ultimate consumption of 3,000,000 tons of fuel oil per annum, which represents an annual saving of 5,000,000 tons of coal. An interesting aspect of the contract is that it provides for the use of low flash point fuel oil at two of the stations. From the viewpoint of the oil company the significance of this provision is that the increasing demand for fuel oil relatively to other fractions of crude oil causes difficulties of refinery balance. By using low flash oil, which will allow a wider range of fractions to be incorporated in the fuel, greater flexibility will be possible at the refineries. The new agreement recalls the contract which was signed last month for the supply of fuel oil by the Esso Petroleum Company, Ltd., to another seven C.E.A. power stations—Littlebrook, Tilbury, Barking, and Brunswick Wharf on the Thames or its estuary, and Poole, Plymouth and Portishead (Bristol). The supply of fuel oil under that contract is expected to increase to about 2,500,000 tons per annum by 1960.

Road Improvement Scheme in Birmingham

ON Friday, July 22nd, the Minister of Transport and Civil Aviation, Mr. Boyd Carpenter, opened the Digbeth highway, a new urban dual carriageway route recently completed in Birmingham. This road widening scheme has cost about £250,000 to complete, and involves a dual carriageway road, 110ft in width and about a thousand yards in length. It is believed to be the only major highway improvement carried out in this country in a heavily built-up area since the war. At the opening ceremony the Minister said that the new road gave a lead in highway development, which was going to be a conspicuous feature in the life of the nation in the next ten or twenty years. A large number of schemes would be begun this summer, he added. During the course of his visit to Birmingham the Minister was shown details of a number of projects for improving the city's roads, including a ring-road scheme.

Proposal for a National Highway Authority

THE latest publication of the British Road Federation, entitled "Make Way Ahead," put the case for the formation of a national highway authority. The Federation points out that such a body would be analogous to those which already exist for railways and canals in the British Transport Commission, and for aviation in the airways corporations. Its functions would be to act as the agency through which road loans could be raised, to co-operate with local authorities in the planning of new roads and major improvements, and to distribute money for new road construction and major improvements with the object of getting new roads built as quickly as possible. The Federation draws attention to the fact that six years have elapsed, without any motorway construction, since the Special Roads Act was passed in 1949, which, the Federation contends, is "clear evidence that serious defects exist administratively, the result of which is to create extraordinary gaps between governmental intention, however sincere, and actual performance." The Federation goes on to say that it is concerned solely that an effective instrument should be created to ensure the building of modern roads in Britain with the speed that the national economy demands. The fact that a modern motorway is a profitable financial investment is stressed in the booklet (an outlay of £200,000 per mile has been estimated to give an annual saving of £25,000 in operating costs), and the road programmes of 1935 and 1946 are recalled. Comparative figures of investments in various other industries since the war are given and it is stated that an annual capital investment of £75,000,000 a year, about 3 per cent of the country's total capital investment, is needed for the roads.

Launch of the Liner "Bergensfjord"

ON Monday of last week, Her Royal Highness Princess Astrid of Norway visited the Wallsend shipyard of Swan, Hunter and Wigham Richardson, Ltd., to launch and name the passenger liner "Bergensfjord," which the company is building for the Norwegian America Line. The ship, which is expected to make her maiden voyage in the spring of next year, has been designed for the service from Norway and Denmark to New York, and also for pleasure cruising. The principal particulars are: length overall, 577ft; length between perpendiculars, 518ft; moulded breadth, 72ft; depth to "B" deck, 38ft; cargo capacity, 1200 tons, and gross tonnage about 18,000. A total of 130 first and 760 tourist-class passengers will be carried on eight decks, the first-class passengers having cabins on the upper sun and sun decks, while the tourist passengers have one, two, three and four-berth cabins on "A," "B" and "C" decks. Most of the public rooms are on the promenade deck, the remainder being placed on the sun deck. The accommodation throughout the ship is air conditioned; in addition, Denny-Brown stabilisers will reduce rolling and add to the passengers' comfort. The hull of the ship is largely welded, only the frames and beams being riveted, and the superstructure above the promenade deck is of all-welded aluminium alloy construction. A normal speed of 20 knots is provided by two double-acting, two-stroke Stork diesel engines, developing a total of 18,600 b.h.p. at 130 r.p.m., each having eight cylinders of 720mm diameter by 1100mm stroke.

Installation of Repeaters in London/Gibraltar Submarine Telegraph Cable

IT is expected that the word carrying capacity of the Eastern telegraph cable from Great Britain to Australia and the Far East may be increased by 50 per cent as a result of recent operations carried out on one of the two cables directly linking Porthcurno, near Land's End, with Gibraltar.

A submarine telegraph repeater was inserted in the cable by the cable ship "Recorder," of Cable and Wireless, Ltd., 150 miles out from Porthcurno. It is the first telegraph repeater to have been put in operation in any of the company's submarine cables. Initial tests made from Porthcurno indicate that the operation was successful. A similar repeater will be inserted at the Gibraltar end of the other direct Porthcurno/Gibraltar cable later this year. These repeaters are capable of one way working only and will be used to work in opposite directions. In the event of an interruption of either cable, however, it will be possible to restore the other to two-way working at the original slower speed by switching the repeater out of the circuit. The first repeater is installed at a depth of some 400 fathoms. Internally, it is divided into three sections: the centre section contains the amplifying equipment and on each side of it there are high-pressure sealing chambers. It was developed for Cable and Wireless, Ltd., by the Post Office Research Laboratory at Dollis Hill.

André Chapelon and the Steam Locomotive

By EDWARD H. LIVESAY

CHAPELON and the locomotive—the terms are synonymous. In the long list of names of engineers who have worked in the field of steam locomotion on rails during the present century, none is more prominent than that of Chapelon; it is probable that no other individual has done more to raise the efficiency of the steam locomotive. For many years his conceptions have been standard practice on various designs of French locomotives, which, it is no exaggeration to say, have "set the fashion" to the locomotive world in more ways than one, and have shown performance of such high order as on occasion almost to verge on the incredible. Not only in France has respect been paid to his well-proven doctrines; in other countries also, and certainly in Britain, his theories have been given high valuation, and practices based upon them have been adopted, though it may be suggested, seldom to the extent deserved. In short, the name Chapelon is inseparable from the machine which to him has been his life; the refinements advocated by him, amply vindicated in practice, have had wide adoption. They will be briefly outlined in this essay, which is based upon several meetings the writer was fortunate to have with Monsieur Chapelon during a recent visit to France; a repeat visit, in fact, made for the purpose of looking still further into the work of engines for so many of which he has been responsible, in which his ideas have been embodied.

In common with most students of locomotive design and performance, I have followed Monsieur Chapelon's work closely for many years, but never anticipated that one day I should meet him in person. It was therefore naturally very pleasing to be greeted by him at the Gare du Nord in Paris on my arrival in the cab of one of his fine "Pacifics" which had brought the "Golden Arrow" from Calais. It was a courtesy all the more appreciated because quite unexpected. I was glad to be able to assure him that the performance of the engine for which he was responsible had been in every way excellent, and its potentialities well demonstrated in the capable hands of Monsieur Leseigneur, Chief of Traction, who had come to Calais on my behalf, as also had Monsieur Fillon, acting as before, on many occasions, courier and interpreter. Our acquaintance, begun under such appropriate circumstances and in equally fitting surroundings, was subsequently renewed and strengthened; I heard much from him that interested me and which, it is safe to assume, will interest readers also.

What, broadly speaking, are the principles generally associated with Monsieur Chapelon—the theories upon which so much of his practice has been based? In effect, they can be outlined fairly simply; they stress the advantage of using high-pressure steam with a high degree of superheat, taken from boiler to compound cylinders through pipes and valves of the largest practicable area and given the easiest possible flow; then, its work done, it should have free exit to atmosphere through similarly large valves and channels, while at the same time as much otherwise waste steam is utilised by means of feed water heaters and/or exhaust steam injectors.

At first sight there may not appear anything very revolutionary about this, and individually there may not be, as all these features were used in some degree before Monsieur Chapelon's day; but in combination, taken as far as is practicable, and regarded as first principles, these factors are of great importance, and until Monsieur Chapelon demonstrated how essential they were they had not been adopted in entirety as fundamental to a locomotive of maximum efficiency. The cumulative result, in economy of fuel and water, gives an overall efficiency of some 12 per cent, the highest figure reached in locomotives of basic design.* This outline of "Chapelon principles," with which I hope he would not quarrel, could, of course, be amplified in detail, but the above is the essence of it.

This combination of harmonious theory and practice, so evident in the latest types of French locomotives, has been acknowledged as desirable, and to some extent has been aimed at and attained, elsewhere, but I suggest the lessons have not always been learned as thoroughly as might have been, nor has Monsieur Chapelon's great experience been drawn upon, nor his advice sought, sufficiently. The former—his experience—plentifully documented as it has been, and exemplified in locomotives doing outstandingly fine work, is open to any designer to emulate. The latter—his advice—I am sure, would never be withheld if asked for, and could not fail to be of great value. One or two examples of reluctance to recognise and benefit from his experience, and that of others working in the same field, will be touched upon later; it is no new thing in the locomotive world, where individuality has often had unfortunate results. Consider the Webb compounds of a day that has gone, for instance!

It was in connection with rebuilt rather than new designs of locomotives that Monsieur Chapelon's ideas were first put into practice, and the benefits of high-pressure steam and superheat, easy steam flow, ample valve area, and so forth, clearly demonstrated. Perhaps this was a good thing, as it gave plainer proof of their correctness than would have been the case had they first been applied to new machines, from which good results would have been expected in any event. The gains made apparent in old locomotives were so marked that cause and effect could be the better traced, and could not be denied; they were seen in engines which, though fully up to the standards of their day, were of comparatively low efficiency, doing their work more or less uneconomically, and in due course would have been relegated to secondary duties, or even scrapped. They were rejuvenated and given a fresh lease of life by rebuilding on Chapelon lines, their earlier crudities replaced by refinements in accordance with his principles, with the result that many of them, often thirty or more years old, are still employed on first-class trains, which they handle as to the manner born. I covered several thousand miles on these engines during my visits to France, finding their work and action to be so nearly equal to that of modern machines that it was difficult to realise they were nearing the stage of sere and yellow leaf. Had they been running elsewhere than in France, without rebuilding, they wonld probably have been scrapped. Watching, from the intimate coign of vantage, the cab, this fine work being done by veteran locomotives, I could not help thinking how much more might have been done in recent years to raise the efficiency of many types of British locomotives by judicious rebuilding and modernising; by taking worthwhile classes having potentialities never fully developed, and remodelling them as nearly as possible on the lines our French friends have proved advantageous; engines which from the first were extravagant of fuel and water and whose virtues were never very evident to anyone but an enthusiast to whom anything in the shape of a locomotive merits encomium, whether deserved or not. Many of these more or less inefficient machines have either been scrapped already or are still rattling around in a condition of neglect sad to see, a nuisance to shed and running people, and often at high cost of maintenance. I have on occasion ridden on such machines, and it has been an unpleasant experience; yet a considerable number of these moribund engines might have been rebuilt with advantage, to some extent at any rate in accordance with Chapelon principles, with benefit to everyone concerned. Rebuilding nowadays does not seem to be as popular as it used to be; scrapping seems to be more the rule. National self-satisfaction is an admirable quality, no doubt, and necessary to a nation's salvation, but it can be overdone, and in Britain, where locomotives are concerned, it sometimes has been. We do not know everything about locomotives, and the French could have taught us several things if we had been a little more willing to learn. And, I imagine, still could!

Almost from the first moment of our meeting beside the engine of the "Golden Arrow" at the Gare du Nord, it was evident that Monsieur Chapelon's interests are not centred exclusively in his own country's locomotives—his studies are far more catholic. He is certainly well acquainted with what is being done in Britain—in production, both past and present. Though naturally his first queries concerned the run from Calais, which had just been concluded, and I was able to compliment everybody on this point, almost at once he brought up the subject of the "Britannias"—how were they doing, had I ridden on them, and what did I think of them? I replied in effect that so far as my information went they were doing quite well on varied services—passenger and freight, express and secondary—now that their "teething troubles," which had been rather serious, were overcome. I added that they seemed to me simple, rugged machines, designed with cost of production and maintenance always in mind, which accounted for the use of two cylinders instead of the more usual—in the past—British predilection in favour of three or four. I suggested that there seemed little originality about them, except in minor details, though I did not say this in any derogatory way. They were merely intended to "carry on" until British Railways are electrified, dieselised, gas-turbinised or "ised" in some way or other, and the puff of the steam locomotive is no longer heard in the land which gave it birth. It followed that they were deliberately designed as simple, straightforward machines, adequate for their purpose and likely to last out their allotted span successfully, but that they did not teach the locomotive world anything it did not

* This 12 per cent efficiency could never be attained without the superheater, and I am not suggesting that Monsieur Chapelon was responsible for that! Nevertheless, he does advocate a higher degree of superheat than is generally used; I noticed over 750 deg. more than once on one or two runs.—E. H. L.

already know—in which they differed considerably from his own productions. Monsieur Chapelon acknowledged the well-deserved compliment with due modesty—in fact, I thought in needlessly deprecatory terms! He asked what the "teething troubles" had been. I mentioned coupled wheels loosening on their axles, calling for the plugging of axle bores in the vicinity of wheels and boxes; connecting-rods proving weak; lubrication of valves and/or cylinders initially a little troublesome, and so on. I could not account for all these shortcomings, in view of the galaxy of talent concerned in the design of the engines. However, apparently they all had been remedied, the class was now widely distributed, and as far as my limited information went the engines were doing good work. As to the way they did it, I felt justified in saying that their riding was not nearly as good as that of the average French engine; it was hard, harsh, vibratory, as though the springs were too stiff, which is as graphic a simile as I can suggest. It has been confirmed by several enginemen with whom I have ridden on these engines, or who had handled them extensively; they said much the same thing. I added—as I was also entitled and competent to do—that I could make the same comparison where the average British engine is concerned, as regards its riding and that of the run-of-the-mill French engine. The behaviour of British locomotives is generally well below that of their Gallic counterparts; even the best of the former do not come up to the French standard, and as to the worst, they were unspeakable. Monsieur Chapelon inquired the reason for this, but I could not advance one, and still cannot. In my experience, covering many thousands of miles on all sorts and conditions of locomotives in both countries, it is a pleasure to ride on the average French locomotive, and pure delight to be on the best, but I cannot be so complimentary with regard to many of my own country's productions, with one or two honourable exceptions. I admit things were far better before the war, but the French railways were hit by that just as much as the British, so that excuse cancels out. Equalisation of springs evidently does not explain the matter; one ageing, but very fine 4–8–2 on which I rode at high speed from Nancy to Paris (THE ENGINEER, June 4, 1954) was uncompensated, yet its riding was perfect. Of course, one would not expect a two-cylinder "Britannia" to be as well-behaved as a multi-cylinder, balanced Chapelon "Pacific" or "Mountain," yet such engines as B.R. "A4" and "A2" classes are both below French standards, though the former was originally regarded as a good riding engine, and was so, in my experience. The latter is a comparatively new type, yet is definitely not good, probably because of some defect in the control of the trailing truck. Enginemen running them are equally critical, though for other reasons they like them. One does not quite see why both types should be less tractable than French engines, though increasing age may be affecting the "A4s," or possibly the fact that engines nowadays never get the attention they did before the war. No, we don't seem able to do it in England!

The four-cylinder compound system with divided drive has so long been associated with Monsieur Chapelon and French locomotives generally that I was surprised to hear that in the unlikely event of further steam locomotives being built for the S.N.C.F. they would be three-cylinder Smith system machines, and I asked the talented designer why he now favoured this arrangement, and had put it into concrete shape in the great 4–8–4 "A1." Had simplicity been the deciding factor, on the score that three cylinders are cheaper to construct and maintain than four? No, he replied, this was not the primary reason, which lay in the difficulty of finding room for bearings of adequate size, at any rate, on a powerful engine, the only type that would be worth building for the S.N.C.F. When two h.p. cylinders are placed between the frames their centre lines would be necessarily 20in or more apart, in which case though there would be room enough for the crank bearings, the axle bearings would have to be curtailed. However, there would be ample space for all three bearings when only one h.p. cylinder was between the frames, irrespective of its size; hence, the preference for the Smith system. Thinking of "U1," the fine 4–6–4 "Hudson"—not a Chapelon, incidentally—a four-cylinder compound with the h.p. cylinders inside, I was about to inquire if this did not rather controvert the point he had made, when fortunately it occurred to me that this outstanding engine was of only 75 per cent the power of "A1," and her inside cylinders were but 17·4in in diameter, with their centre lines correspondingly closer together; in that case, there was room for everything—the four bearings. A pair equivalent in power to the single h.p. cylinder of "A1" would have their centre lines approximately 22in apart, which would curtail the axle bearings considerably. Incidentally, "A1" develops about 4000 i.h.p.

A HYPOTHETICAL "PACIFIC"

This exposition of Monsieur Chapelon's views was so interesting that I was content to listen rather than have the hardihood to advance my own, but the subject came up again later. It has already been said that his locomotive interests are catholic, and certainly include British practice; indicative of the latter, a photograph of the new class "8" B.R. 3-cylinder "Pacific" stood on his desk. He regretted that the 3-cylinder compound system had never been taken beyond the very successful medium power ex-Midland 4–4–0's, which will soon be extinct; he was of the opinion it could have been done, notwithstanding British loading-gauge limitations. Complication, a bugbear that used to be raised against the compound, had no validity, bearing in mind the many three and four cylinder simple engines subsequently built in Britain. The only additional mechanism needed for a compound is an intercepting valve, independent valve-gear for h.p. and l.p. cylinders not being necessary. This affirmation, that the Smith system could have been taken further in Britain, struck a responsive chord in his listener; I thought the same thing many years ago when the "Pacific" type of engine was first mooted in Britain, and made its appearance in the Gresley 3-cylinder simple class—disregarding the ephemeral "Great Bear." I had pictured just the sort of engine Monsieur Chapelon was advocating; a powerful 3-cylinder Smith system "Pacific," quite a possibility even though our loading gauge limits outside cylinders to about 22in in diameter if the connecting-rods are outside the coupling rods—they are inside on the ex-Midland 4–4–0's. I was about to remind Monsieur Chapelon of this gauge and cylinder limitation, and ask whether he agreed that there was one way round it—high steam pressure—when he began sketching a plan of the type under discussion—a Smith system "Pacific" for British Railways. Very interested, I watched the thing taking shape, following with the help of the interpreter Monsieur Chapelon's running commentary, and thinking how fortunate it was that I had not forestalled him with my own amateur conception—a pupil should not rush in and anticipate a Master! Finally his facile pencil was laid down: there lay the attractive outline with all its suggestive possibilities—a plan of the engine that might have been. I was about to compliment him upon it, while at the same time pointing out with diffidence that the sketch gave no indication of what seemed the vital factor for the success of the plan, so far as a British machine was concerned, when, as if the result of thought-transference, he jotted down the steam-pressure—314 lb. So my own idea had not been either visionary or impractical—balm to my soul! It would have been a powerful machine, even limited to 22in l.p. cylinders; presumably reinforced compound working would have been provided for. I have since regretted not asking for this sketch as a souvenir of a very interesting interview; it would have given point to this essay.

The 314 lb pressure, or a figure of that order, would have been necessary to obtain sufficient power, and in view of the objections that would certainly have been raised against it—and probably still would be in Britain—I asked if the cost of building and maintaining a boiler to carry this pressure might not more than offset the economy and other advantages of the design. Monsieur Chapelon's "Non!" was emphatic. He said that provided the boiler and firebox were properly designed to stand a high pressure, the additional cost of maintaining it was chimerical, but it was essential that everything affected by the high pressure, including fittings, glands, &c., should be designed accordingly. Where trouble had arisen in the past was due to primary mistakes; in particular where the pressure had been stepped up in a boiler beyond the figure it was originally designed to stand, to take care of which there had been inadequate compensation. He instanced some big 4–8–2 engines running in the S.W. district, I believe, with which this mistake had been made. The pressure had been raised considerably, and though what was judged to be adequate strengthening had been introduced, so much trouble resulted with various details that the pressure had to be cut back to the original figure. Though 314 lb may seem high, 300 lb was quite common in North America in the latter days of the steam locomotive, and 290 lb is at present not regarded in France as anything out of the way, or to be avoided. But in Britain apparently anything over 250 lb is still looked upon with suspicion; instance the Bulleid "Pacific" on which I rode to Folkestone with the "Golden Arrow" last year en route to France, which had its pressure cut down from 280 lb to 250 lb. Whether this had been done to reduce cost of maintenance, or because the engine developed enough power for the work it had to do with the 250 lb. pressure, I cannot say.

Monsieur Chapelon questioned me about the new B.R. class "8" "Pacifics," but I could say little about it, not having had up to then any experience of the only example running. I had heard that the rotary-cam poppet valve gear had come in for a certain amount of attention—more "teething-troubles" presumably. He expressed surprise that this type of gear had been adopted, he himself having a decided preference for the oscillating cam pattern. I asked whether he had been approached by British locomotive people on the subject of poppet-valve gears generally,

as his experience with every kind of gear could not fail to be of value, in view of the much greater familiarity French engineers have enjoyed with this mechanism than their British compeers—poppet-valve gears have been almost standard practice in France for at least a quarter of a century. His reply was in the negative ; can one look on this as an instance of somewhat overdone national self-satisfaction ?

The latest types of French locomotives are fitted with piston-valves, seen in the fine 4–6–4 " U1 " (THE ENGINEER, March 5, 1954), and in the equally outstanding " P " class (THE ENGINEER, April 16, 1954) ; similarly, in the unique 3-cylinder " Smith " system compound 4–8–4 " A1 " (THE ENGINEER, May 21, 1954), which unfortunately will remain sole exemplar of its class. Poppet-valves have been discarded not so much on the score of improving distribution as on grounds of simplicity and lower construction and maintenance cost. In theory, poppet-valves gears are claimed to be improvements on the older type, but one notices that, after extensive trials, the piston valve is often taken back into favour again, which seems to have been the case in France. Monsieur Chapelon's great experience with a variety of gears might have been drawn upon by British designers with advantage, not only recently, but in the past. For instance, going back a considerable period, if he had been consulted it is possible the Gresley conjugated gear might not have been adopted, as it has long been recognised that it gives incorrect steam distribution in the middle cylinder, intensified when wear takes place anywhere about the mechanism. It was consoling to find my humble ideas about it correct, and that Monsieur Chapelon did not favour it, and has not fitted it to 3-cylinder engines.

Another example of disinclination to draw upon the greater experience of others is seen in the case of the British diesel-electric locomotives. These have been running for upwards of ten years, yet it is understood that their " teething troubles " have never been overcome, and reliability is still far from what it should be. Would it not have been possible some time ago to have obtained a couple of standard American diesel-electrics, and then, after extensive experience with them, design machines of our own, if possible improving on the prototypes ? Modifications, of course, would have had to be made in the engines to suit the British loading gauge, but this would probably have been feasible, the power of typical British and American units being much the same, about 1500 h.p. The Americans have been building this kind of machine for twenty years ; many thousands have been turned out, and they are almost standardised ; in fact, two-thirds of American trains are now diesel hauled, and Canada is following fast in the same direction. In a word, trans-Atlantic designers and railway men have had vastly greater experience of this kind of motive power, and though it may go against the grain to admit it, and take advantage of it, it is probably advisable to do so, as it is in no way discreditable, and the Americans never scruple to do the same thing when it is to their benefit. Instance the gas turbine, jet propulsion, and many other equally cogent examples.

Independent working and control of the two sets of valve gear, h.p. and l.p., always looked upon as a salient feature of the four-cylinder compound engines, long favoured in France, has now been discarded, and on inquiring from Monsieur Chapelon why this was so, his answer was much what I expected. He said that in the hands of an expert and painstaking man no doubt somewhat better results could be obtained by using different length of travel in the two sets of cylinders according to what was demanded of power, speed and gradient. This called for not only both theoretical and practical knowledge, but willingness to take the trouble to make the frequent changes necessary to give effect to these qualifications. Drivers with all these attributes are not found in every cab ; there are quite a number of exceptions ; in effect, they are not all Leseigneurs ! Hence the locking gear used on four-cylinder engines, by which the two sets can be operated as one, and finally, the discarding of independent operation altogether, it having been found that in the long run satisfactory results were obtained by approximately the same cut-off in both h.p. and l.p. cylinders when an engine was in average hands. In this way the driving is simplified considerably, a complicated four-cylinder engine being handled exactly as a simple expansion machine. This was stressed in the description of 4–6–4 " U1 " (THE ENGINEER, March 5, 1954), the statement being taken from the official journal of the S.N.C.F. Obviously, it is by no means easy to get the best results from a compound engine with independent valve gears, as not only do these have to be correlated, but this cannot be done subjectively unless the steam chest gauges, both high-pressure and low-pressure, are consulted, too ; a really conscientious driver might even feel obliged to call in the help of the exhaust pressure gauge as well ! All these gauges are found on French engines, but it is surely asking too much of the average driver to harmonise this multiplicity of interacting controls and gauges over a fluctuating route. Personally, I found it very difficult just to keep track of what was happening at the front end, and I merely had to watch the controls and dials, without deciding what to do about them. I never really succeeded, finding all I could achieve was approximation, not perfection. That is what they evidently found on the S.N.C.F.; better simplify the job down to the level of the average driver.

QUALITY OF COAL

So many interesting subjects came up during my talks with Monsieur Chapelon that it is impossible to cover them all, even if I could recall them accurately—which I cannot. I have often wished since that a reporter had been present to take everything down verbatim to do justice to Monsieur Chapelon's commentary. Though naturally I listened rather than attempted to advance views of my own, I remember once rather putting my foot in it by referring in derogatory terms to the poor coal noticed on several occasions, though, at the same time, taking the edge off my criticism by complimenting everyone concerned on the fine work done in spite of it. Monsieur Chapelon's riposte was a prompt denial that the coal was bad—in fact, he said, express engines got good coal. To some extent I agreed, admitting my indictment was rather too sweeping ; on express runs good coal had been noticed, particularly where the engine was mechanically stoked ; the coal had evidently been screened and was of even size and good quality, the conveyor merely having to convey, not crush as well. But on freight runs and others made on secondary services, particularly during my second visit, I did see plenty of inferior coal, much of it pure dust, so fine that had the blast been at all vigorous much of it would have been pulled straight through the firebox into the tubes, and waste would have resulted. But in France most engines are compounds, with correspondingly soft exhausts, so this is not likely to happen to any great extent. It was explained that railway coal is screened and sorted at the pits, the different grades being distributed for services in order of importance, express engines getting the best and freights the worst. On some of the freight runs the firemen made no secret of what they thought of the stuff they were handling, and though I could not give a literal translation of their remarks the sense of them was so obvious that I was both amused and sympathetic. I hasten to say that we in Britain nowadays have no reason to assume airs of superiority where locomotive fuel is concerned ; the days when the coal seen on British tenders was almost uniformly good are but memories. I have made trips recently when deplorable stuff was being used, with plentiful admixture of slate and stone ; that, at any rate, I never saw in France. Rocking grates, self-cleaning smokeboxes, side-discharge ashpans, &c., are provided on new British engines, for the same reason they were found necessary long ago in France, so now we are in the same boat. Notwithstanding that in Britain, as in France, the day of the steam locomotive is nearing its end, we shall have this motive power with us a good while yet, and we can still learn lessons from France on getting the best results from the inferior fuel we are likely to have in future.

RETIREMENT

Meeting as I did during my visits with all ranks and ratings of S.N.C.F. officials and enginemen, often becoming on intimate terms with both, it appeared to me that the latter at any rate seemed fairly contented with their lot, and took a pride in their job. I noticed, too, the comparative youth of the mecaniciens, though this did not apply so much to the " chauffeurs "—comparative as to their British opposite numbers, I mean —there are plenty of youngsters handling the shovel on B.R. these days. Really elderly drivers were conspicuous by their absence, and the mystery was explained by Monsieur Chapelon—the retiring age for enginemen is fifty. This certainly seems somewhat too previous ; at that age a man might be physically little past his prime and mentally at the peak. Monsieur Chapelon agreed, and other officials, I found, took the same standpoint ; however, nothing can be done about it, as the men like it, their attitude no doubt being affected by the fact they receive a substantial pension—in which they score over British railwaymen. When, a little while ago, it was seriously proposed to raise the retiring age, there was strong opposition, to the extent of threatened strike action, so the idea was dropped, and is not likely to be revived. Presumably, the pension scale is sufficiently generous for the recipient to live upon it, without the necessity to augment it by whole or part-time work, and here again the French system is better than ours. More than one British engineman has complained to me that on retirement at sixty-five they would have to get further employment or lower their standard of living, which they considered none too high anyway. I cannot give facts and figures on French enginemen's wages, not having been willing to pry into such matters on short acquaintance, no matter how pleasant my relations with them may have been—and they always were. I would not even do it in England ; there it has always been volunteered when touched upon at all. Still less

would I be so tactless and "nosey" in another country! Incidentally, officials also retire earlier in France than is the case with us—at fifty-five/sixty, I believe.

The steam locomotive having been Monsieur Chapelon's life-work, to which his heart and mind have been devoted, it is not surprising that he contemplates the complete electrification of the French railway system with mixed feelings. For many things he regrets it, no doubt, as many of us do; the passing of what has been part and parcel of our lives, with which we grew up; but, in common with such, he recognises the necessity for the change over, its advantages and inevitableness, and would not decry it. I gathered he thought the conversion was being made somewhat too hastily in certain areas, before it was necessary or justified, where steam traction could still show operational economy. Full electrification is undoubtedly the logical solution of France's railway problem, short as she is on coal, long on water power, and with heavy and increasing traffic on many routes. One may regret that sentence was passed upon the steam locomotive so suddenly, inasmuch as several very interesting types of advanced design, for which Monsieur Chapelon was responsible, were stillborn, never getting beyond the drawing board. First of all the war delayed their construction, and then the decision to electrify the whole of the S.N.C.F. put a final veto on the programme. Four classes were planned, three-cylinder compounds, standardised as far as possible where boiler, cylinders and associated details were concerned, differing only in the wheel arrangement and diameter appropriate to the duties on which they were to be employed. They were respectively:—(1) 4–8–4 mixed traffic, (2) 2–8–4 mixed traffic, (3) 4–6–4 express, (4) 2–10–4 freight. Two further designs were tentative, though not definitely envisaged—they were possibilities, fanciful, though practical. One was a light 4–6–4 tank engine, arranged for one-man operation, on secondary services now being handled by diesel "autorails"; the other, a light high-speed 4–6–0 tender engine would have been suitable for such fast running as the pneumatic-tyred Paris/Strasbourg trains (THE ENGINEER, May 28, 1954), which are still steam operated, that line not having been electrified; they would have been capable of 120 m.p.h. One cannot look at these fascinating designs without feeling regret that none of them took shape, and probably never will, though there might be a possibility of something resembling them ultimately being built for use in parts of the world where the steam locomotive has a longer lease of life.

As chief of the Division of Study and Design, S.N.C.F., Monsieur Chapelon was responsible for all the steam locomotives on that system, and everything connected with them, but his activities were not entirely confined to that sphere; he was frequently called upon to place his experience at the disposal of outside organisations. In 1949 the "Gelsa" export group of French locomotive manufacturing companies, a quartette comprising Batignolles/Chatillon, Cail, Creusot and Fives/Lille, contracted to build 90 metre-gauge engines for the Brazilian Government, twenty-four to be of the 4–8–4 type and sixty-six of the 2–8–4. The four firms acted together, with Monsieur Chapelon at the head of the combined staffs as co-ordinator and adviser, the first engine of the ninety being completed at the Nantes works of Batignolles/Chatillon in 1951. Both are two-cylinder simple machines, special regard being paid to the fact that Brazilian coal is of low calorific value. The fireboxes are large, with two siphons, ample grate area and mechanical stokers. The 4–8–4 class is somewhat larger than the other, the firebox having a combustion chamber, and the driving wheels are 4ft. 8in in diameter; the smaller class has 4ft 2in wheels. Both types have cylinders of the same diameter, but differing in stroke, this being longer in the case of the large machine with its 4ft 8in wheels. As many of the details as possible in the two machines are similar, both being the outcome of the combined experience of the four companies, plus that of Monsieur Chapelon, who is now consulting engineer to the Batignolles/Chatillon firm, following his retirement from the S.N.C.F. This being so, it is probable his great experience as a locomotive designer will find further scope in the sphere he has made so much his own. The meetings I had with him in France are not the least memorable among the pleasant recollections of my associations with the S.N.C.F., and I am correspondingly grateful for the invaluable assistance received from him and his assistants.

Geophysical Prospecting

By ROLT HAMMOND, A.C.G.I., A.M.I.C.E.

No. II—(*Continued from page 105, July 22nd*)

Airborne Magnetometer Surveys

AIRBORNE magnetometer surveys are applicable to a wide range of geological investigations, some of which may be briefly summarised. Base metal sulphides occur in a given area as replacements in a shear zone, particularly where the shear cuts a formation. If shears and other features can be interpreted from magnetic data, promising localities can then be selected for detailed prospecting by other methods. When such ores as magnetite or pyrrhotite are known to be associated with the ore minerals in question, magnetic data should be studied with special care in those localities known to be promising. Some sulphides of base metals are closely associated with basic, highly magnetic intrusive rocks. This is generally true of nickel deposits, and all strong anomalies should be investigated in areas where this metal is expected to occur.

Gold normally occurs in or near zones which have suffered structural deformation, in stratified rocks like lavas and sedimentary deposits. Large structures can often be detected and outlined in these formations, thereby concentrating exploration on areas likely to show good results. Large masses of granitic rocks, with which gold deposits may be related, may also be outlined by magnetic survey.

When the topography of the strata underlying oil-bearing rocks can be calculated from a magnetometer survey, an economical method is available on which to base further exploration. The latter will probably entail seismic surveys and test boring, but if the areas are limited in size then an immense saving in time and money can be effected, because only those areas likely to show results will be investigated. The airborne magnetometer has been used with outstanding success to outline salt domes which, in many cases, have yielded considerable quantities of oil.

Asbestos is a very valuable industrial mineral which nearly always occurs in serpentine, a rock with high magnetite content, developed by metamorphism. Strongly magnetic zones should therefore be examined and, if they prove to be serpentine, should be carefully outlined; subsequent efforts can then be focused on the relatively small area likely to contain asbestos. It is believed by geologists that asbestos has been formed where bodies of serpentine have been shattered by faulting, which can often be detected magnetically. Chromite generally occurs in highly magnetic intrusive rocks, so that areas of low magnetic intensity can be virtually eliminated when prospecting for chromite deposits. Where a precise relationship can be established between chromite bodies and geological features, such as faulting and intrusions, then the search can be narrowed still further.

A magnetometer survey can help in the discovery of new coal deposits only by revealing areas in which the sediments are thickly deposited. Folds and faults may be detected in coal-bearing strata by a study of the underlying complex, knowledge of special value when investigating coal reserves that extend beneath the sea. Similar problems are presented by deposits of gypsum, salt and dolomite.

Hæmatite is the most important ore of iron and is generally non-magnetic, although the variety known as specularite shows slight magnetism. Magnetic intensities over a large body of hæmatite are apt to be less than those of the surrounding rocks, particularly when the latter are igneous or metamorphic. The magnetometer is claimed to be ideal for detecting iron formation and outlining structures affecting this material. When uranium deposits are associated with dykes and sills, the magnetometer will localise the search, so that subsequent detailed investigation can be made with Geiger counters or other equipment.

The search for water is a very important engineering activity, and probably water occurs under a greater variety of geological conditions than any other mineral resource. A magnetometer survey will reveal the main geological features useful in finding water. The search for ground water by magnetometer is becoming increasingly important, since it depends very largely on an accurate knowledge of sub-surface geology.

The metal titanium is to-day becoming increasingly important in engineering, ilmenite being the principal ore from which it is manufactured. This ore has been discovered in large quantities in a relatively magnetic igneous rock known as anorthosite. Aeromagnetic surveys across the ore bodies show low, uniform values as compared with those obtained over the anorthosite. The magnetometer gives excellent results in prospecting for titanium.

In recent years the increasing use of light alloys has stimulated the search for bauxite, the principal ore of aluminium. Deposits of this ore and parent rocks are often buried deeply beneath sedimentary strata. Magnetometer surveys have given valuable results in revealing buried hills of syenite, on the flanks of which bauxite is formed.

In the system of airborne magnetometer prospecting sponsored by Hunting Geophysics, Ltd., the earth's magnetic field is continuously recorded as the aircraft containing the magnetometer is flown at a given altitude. Under certain conditions, a few of which have been outlined above, this instrument can be employed to reveal the geological structures in which a wide variety of minerals can reasonably be expected to occur.

Magnetite is a highly magnetic mineral,

having stronger magnetic properties than any other mineral, so that concentrations are easily detected by an airborne magnetometer survey, except where such a concentration is either small or deeply buried. Pyrrhotite is second on the list of magnetic minerals, and although its magnetic properties are much less than those of magnetite, they are still very strong. It is, however, impossible to distinguish concentrated pyrrhotite from disseminated magnetite on a magnetic basis alone ; since pyrrhotite is commonly found closely associated with sulphides of the base metals, particularly copper and nickel, in this respect it has special magnetic significance.

Most mineral deposits are not markedly magnetic ; even where a disseminated magnetic mineral is associated with the mineral being sought, magnetic effects may be too slight to provide adequate indication. Sometimes a large body of valuable material differing in magnetic properties from its host rock may be mistaken for a change in rock type ; in such a case careful study must be devoted to local and regional geology, thereby combining geological observations with magnetic interpretation.

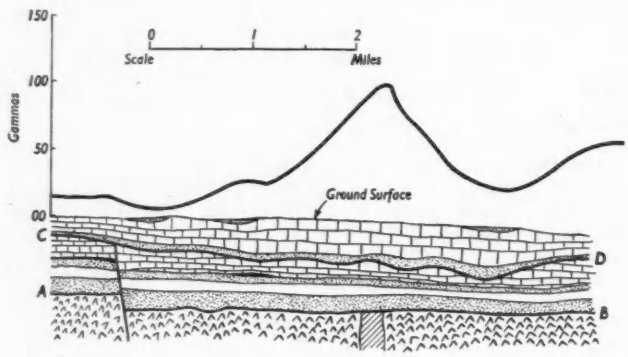


Fig. 4—Magnetic profile obtained at 1000ft above the surface over oil-bearing strata

The main point to emphasise is that magnetite is so strongly magnetic in comparison with other minerals, that when it occurs in a rock it is the main factor in establishing the magnetic properties of that rock and nearly all rocks contain some magnetite. If the magnetite content of a particular formation is reasonably constant, the rock will have a constant and characteristic field associated with it ; thus, a formation may be magnetically high, low or intermediate. Formations containing silicates rich in iron, like olivine, pyroxene and hornblende, will have greater magnetic permeability than those lacking such minerals.

A rock formation can be outlined from a magnetometer survey if certain conditions apply. Its magnetic properties must be characteristic and clearly distinguishable from those of adjacent formations ; the rock should extend to considerable depth and a steeply dipping formation will fulfil this requirement ; the formation should be bounded by contacts which have a moderate or steep dip, so that steeply dipping formations are again ideal.

In the exploitation of mineral deposits an airborne magnetometer can yield much information on geological structure in a very short time, but it is essential to study aeromagnetic data in conjunction with air photographs for structural interpretation. Magnetic contours generally follow the surface outlines of tilted strata, more particularly where adjacent strata differ widely in their magnetic properties. Direction of dip can often be determined from a study of the magnetic profiles over relatively magnetic horizons. If the magnetic properties of that horizon are known, calculation of the approximate degree of dip can be made. Folds can be traced from variations in magnetic trends, providing that the folds are plunging. Folds lying horizontally may escape detection unless reversals of dip can be recognised. A fault traversing a structure will generally produce a break in the magnetic trend lines, owing to the presence of different formations on each side of the fault. If a fault is suspected from magnetic evidence, then it is sound practice to consult air photographs. The existence of a linear topographical feature, such as a series of narrow swamps, the valley of a stream, or sharp crevices in outcrops, will generally reveal the exact location of a fault if the overburden is not too deep.

Where igneous intrusions are large and have a characteristic magnetic field, interpretation is relatively simple. Igneous dykes may show up in aeromagnetic records, particularly if such dykes are wide and cross the regional structure at an appreciable angle ; a dyke may be most easily detected where it crosses formations having contrasting magnetic properties.

In Fig. 4 the curve is the magnetic profile taken at a height of 1000ft above ground level, over oil-bearing strata. The strong magnetic anomalies in the right-hand portion of the profile are related to basic rocks in the basement complex. The smaller anomalies on the left are caused by uplifts in the surface of the basement. This surface is marked *AB* and an uplifted fault block appears near the left-hand side of the section, with the fault passing upwards into the younger sediments. Near the centre of the section is a buried hill or a later structural uplift, but in either case the feature is reflected in the overlying strata as a compaction fold or structural dome. Any of these structures will provide possible traps for oil and gas, as indicated by the solid shading. The line *CD* represents an unconformity due to erosion and is commonly found in a deep sedimentary series of strata ; the rocks above completely mask the important underlying structures.

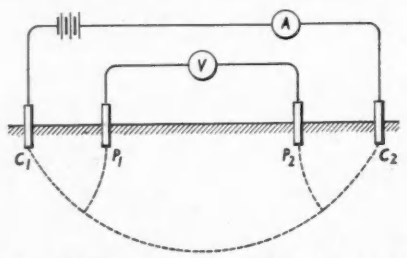


Fig. 5—The Wenner system of placing electrodes for resistivity survey

An airborne magnetometer survey has many outstanding advantages, but if it is supplemented by air survey, the air photographs can be extremely useful when carrying out subsequent geological work in a district. Profiles can be recorded at 135 m.p.h. and in good weather more than 1000 miles of profile may be measured in a day. Modern airborne and ground magnetometers can measure the earth's magnetic field to an accuracy greater than is required by most surveys, measurements being continuous and plotted automatically as a continuous profile. An airborne survey is best suited for large areas, and although results are less detailed than those obtained from ground surveys, they often give a clearer picture of regional features and the method is therefore valuable for reconnaissance work.

Electrical Resistivity Methods

The electrical resistivity method is a well-established technique which gives excellent results in practice and can be applied to a wide variety of work, being both rapid and economical. It hardly needs to be emphasised that in both this and all other geophysical methods, interpretation of results should be in the hands of well-trained experts with a background of sound geological knowledge. The method consists of passing a known electric current through the ground from one point to another, and measuring the difference of potential between two intermediate points ; readings are interpreted in accordance with the pattern and spacing of the electrodes. Many different techniques have been evolved to suit various problems, but the most widely known is the Wenner system shown in Fig. 5, often referred to as the four-electrode system, from which other techniques are derived. The principle is that when four electrodes are symmetrically spaced, their spacing is proportional to the effective depth of penetration of an electric current passing through the two outer ones, as indicated in Fig. 5.

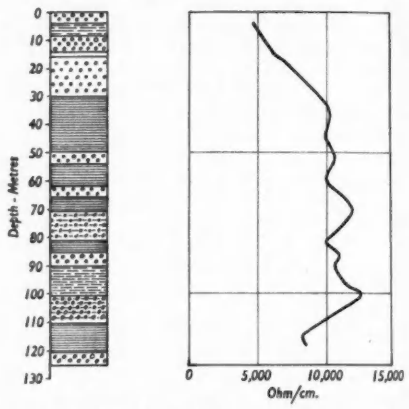


Fig. 6—Depth probe, on right ; borehole log, on left

In homogeneous ground, this principle can be expressed by the following formula : $P=2\pi \times a \times R$, where P is the resistivity, or specific resistance of the ground, a is the electrode spacing ; R is the total resistance in ohms between $P1$ and $P2$. In practice, however, perfectly homogeneous ground is a theoretical concept, so that the above formula becomes empirical to an extent depending upon such factors as grain size, porosity, moisture content and stratification. If correct results are to be obtained, it is, therefore, necessary to evaluate these variables and modify the formula, or to use the formula as it stands and to correlate results with borehole data, a procedure claimed to give an accuracy of about 5 per cent.

A given area may thus be surveyed either by a number of depth probes, like the one shown in Fig. 6, or by constant separation traverses, a series of observations in which a constant electrode spacing is used at a

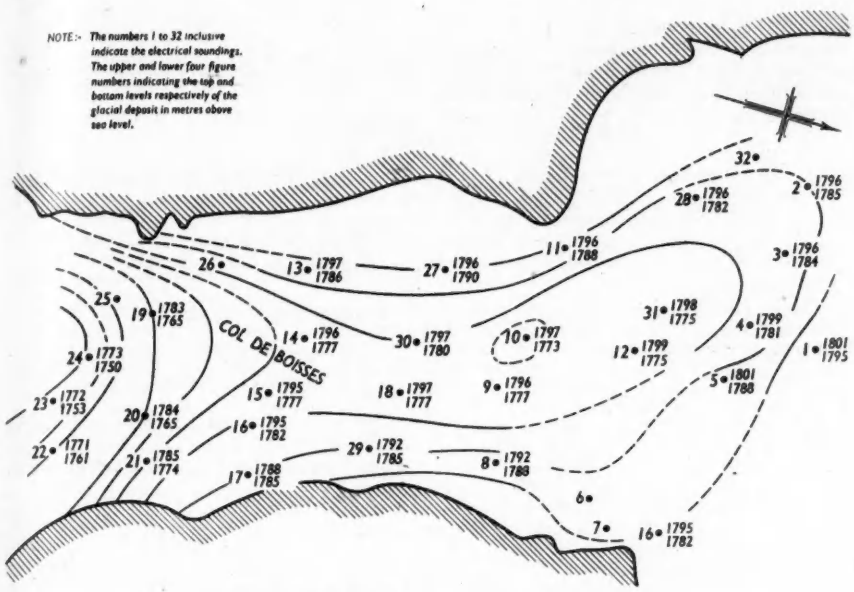

NOTE:- The numbers 1 to 32 inclusive indicate the electrical soundings. The upper and lower four figure numbers indicating the top and bottom levels respectively of the glacial deposit in metres above sea level.
COL DE BOISSES

Fig. 7—Geophysical survey at site of Tignes dam

number of stations on a line or grid ; under normal conditions, a combination of both techniques is employed, although there are cases where the latter is not suitable. Spacing and manipulation of electrodes can be varied to suit different problems and site conditions, but the central-electrode system shown in Fig. 8 is widely used ; there are still four electrodes, $C1$ being placed at a theoretically infinite distance from $C2$ and left there while the other three electrodes are moved about. The so-called " infinite " distance is never allowed to become less than $10D$, but its maximum value is limited by practical considerations such as the length of wire available.

This system has the advantage of speed in operation and with increasing values of D a sudden change of resistivity will become

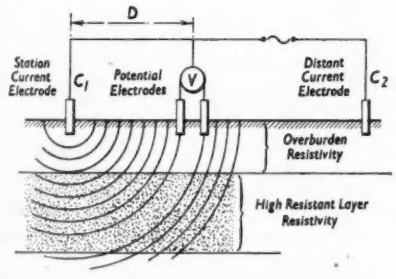


Fig. 8—Central electrode system of carrying out resistivity survey

apparent as the bottom of the shell cuts an interface between two strata. Scope of this system is somewhat limited, and a further disadvantage is that when high values of D are accompanied by low values of R, small errors of observation may be unduly magnified.

In the electrical resistivity method used by Le Grand Sutcliff and Gell, Ltd., three main types of instruments are employed, namely : a Megger earth tester, a Geophysical Megger, and a milliammeter-potentiometer with either batteries or generator, all of which are made by Evershed and Vignoles, Ltd. The first two instruments operate on a fixed current and their respective depth limits are about 60ft and 400ft under average conditions, although much greater depths can be reached in areas of high resistivity. With the third item of equipment, however, current can be varied and range increased to a maximum depth of 1000ft by increasing the voltage.

Although field work with the resistivity method is relatively simple, correct interpretation of results demands high skill and long experience. For example, it is easy to confuse a water table in gravel with an interface between dry gravel and clay, because both will give very similar resistivity characteristics ; similarly, a large cavity in limestone filled with air may be mistaken for an igneous intrusion. In many cases, and more particularly where various strata occur, reliable results can be achieved only by correlating resistivity data with bore-hole logs. Having correctly interpreted and correlated a number of probes in a given area, an iso-resistivity plan may be drawn, a study of which will enable the general rock structure of the region to be interpreted.

Examples of Resistivity Surveys

An excellent example of a resistivity survey is that carried out by the Compagnie Générale de Géophysique in connection with the Tignes dam on the Isère at Pont de Chevril, France. The water level of the impounded reservoir is at 1792m above sea level, so that the water nearly reaches to the Col de Boisses at a distance of about 600m from the dam. Bedrock is not visible at the site of the dam because it is covered by glacial deposits ; the surroundings take the form of outcrops of Triassic quartzite, but at the Col de Boisses itself there are only quaternary formations and the impermeability of the basin naturally depends on the thickness and impermeability of those quaternary deposits.

From the electrical resistivity point of view, the problem involved measurement of the thickness of the relatively conductive glacial strata (ranging from 100 to 500 ohms) which rest on a base of quartzite with practically infinite resistance. Thirty-two electrical soundings were made as indicated by the numbers against the black dots in Fig. 7, which also shows top and bottom levels respectively of the glacial deposit. A single check borehole was sunk at electrical sounding No. 9 ; this revealed a depth of 20·5m of glacial deposit, the depth measured electrically having been 19m, a remarkably close agreement.

(*To be continued*)

Expressions for Circular Section Bow Girders Carrying a Concentrated Load

By W. JOHNSON, B.Sc.(Tech.), A.M.I.Mech.E.

Simple expressions for the analysis of bow girders of circular or tubular cross section are described in this article. These expressions may be applied to any particular plan shape.

THE application of Castigliano's First Theorem to bow girders carrying a concentrated load, for the purpose of determining deflections, support reactions and moments, frequently leads to integrals which are laborious to evaluate and which, in instances where the member has not a simple centre line, may require two tedious graphical integrations, one to deal with the strain-energy due to bending, the other with strain-energy due to twisting. However, for girders of solid circular section, or circular tubes with concentric bore, i.e. those cross

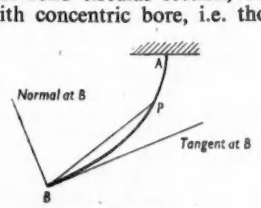


Fig. 1

sections which in bending and torsion have planes remaining planes, certain simple expressions may be obtained. It is because of this warping of initially plane sections that, when non-circular sections are to be treated, the ratio of bending to torsional modulus has to be derived experimentally and can only occasionally be calculated. The error in the results below is variable ; it is always less than about 12 per cent and sometimes zero. The formulæ derived are not limited to any particular plan shape and in this is their value. Here, as is customary, deflection due to shear force is neglected.

Members Built-in at One End Only

Fig. 1 shows, in plan, a plane horizontal member AB, of uniform cross section built-in

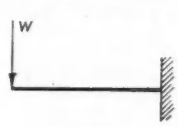


Fig. 2

at right angles to a wall at A and carrying at B a single vertical load W, a bending moment M_0 and a twisting couple T_0 ; these latter two quantities are vectorially represented in Fig. 3. The structure is shown in elevation in Fig. 2. AB is subject to combined bending and torsion. We proceed in the usual manner by obtaining the couples M_p and T_p parallel

and perpendicular to the tangent at P, any point on AB (see Fig. 4) :

$$M_P = M_0 \cdot \cos(\theta+\psi) + T_0 \cdot \sin(\theta+\psi) - Wr \cdot \cos\psi.$$
$$T_P = -M_0 \cdot \sin(\theta+\psi) + T_0 \cdot \cos(\theta+\psi) + Wr \sin\psi.$$

Preparing to apply Castigliano's first theorem, we determine the strain-energy due to the bending and twisting couples,

$$U = \int_B^A \left(\frac{M_P^2}{2EI} + \frac{T_P^2}{2GJ}\right) \cdot ds \quad . \quad . \quad (1)$$

EI is the flexural rigidity and GJ the torsional rigidity. Now simplify (1) by noting that for the members considered,

$$\frac{EI}{GJ} = \frac{(1+\sigma)}{1} \doteqdot \frac{1 \cdot 3}{1} \quad (\sigma \doteqdot 0 \cdot 3 \text{ for steel}).$$

Equation (1) may be rewritten :

$$2U \cdot (EI+GJ) = 2\int (M_P^2 + T_P^2)\, ds$$
$$+0 \cdot 3 \int T_P^2 \cdot ds - 0 \cdot 23 \int M_P^2 \cdot ds \quad . \quad (2)$$

or, approximately,

$$U \doteqdot \frac{1}{EI+GJ} \cdot \int (M_P^2 + T_P^2) \cdot ds$$
$$\doteqdot \frac{4}{7EI} \cdot \int (M_P^2 + T_P^2)\, ds \quad . \quad . \quad . \quad (3)$$

Now,

$$M_P^2 + T_P^2 = W^2 \cdot r^2 + M_0^2 + T_0^2$$
$$-2W \cdot M_0 \cdot r \cdot \cos\theta - 2W \cdot T_0 \cdot r \cdot \sin\theta.$$

Therefore

$$\int (M_P^2 + T_P^2) \cdot ds = W^2 \int r^2 ds + (M_0^2$$
$$+T_0^2) \cdot \int ds - 2WM_0 \int r \cdot \cos\theta \cdot ds$$
$$-2 \cdot WT_0 \int r \cdot \sin\theta \cdot ds.$$
$$= W^2 \cdot J_B + (M_0^2 + T_0^2) \cdot S - 2W(M_0\bar{x} + T_0\bar{y}) \cdot S.$$

where J_B is the "polar moment" of centre line of member about B ; s is curved length from B to A ;

and

$$s\bar{x} = \int r\cos\theta \cdot ds \text{ and } s\bar{y} = \int r \cdot \sin\theta \cdot ds$$

where $\bar{x}$, $\bar{y}$ are respectively the distance of the centroid of AB from the normal and tangent at B.

Thus, vertical deflection at B,

$$\Delta_v = \frac{\partial U}{\partial W} = \frac{8(W \cdot J_B - M_0 s\bar{x} - T_0 s\bar{y})}{7EI} ; \quad . \quad (5i)$$

angle member bends through,

$$\theta = \frac{\partial U}{\partial M_P} = \frac{8s(M_0 - W\bar{x})}{7EI} ; \quad . \quad . \quad . \quad (5ii)$$

angle member twists through,

$$\phi = \frac{\partial U}{\partial T_P} = \frac{8s(T_0 - W\bar{y})}{7EI} \quad . \quad . \quad . \quad . \quad (5iii)$$

As an illustration suppose we have the simple case of a quadrant carrying a single end load W, Fig. 6 ; then, using (5i) we have,

$$\Delta_v = \frac{8J_B}{7} \cdot \frac{W}{EI}, \text{ (since } M_0 = T_0 = 0).$$

$$J_B = \int r^2 ds \doteqdot 1 \cdot 14a^3 \text{ and } \Delta_v = 1 \cdot 30 \cdot \frac{Wa^3}{EI}.$$

Using the exact method

$$\Delta_v = 1 \cdot 25 \cdot \frac{Wa^3}{EI}.$$

Member Built-in at Both Ends

If we can calculate the bending moment M_0 and torque T_0 under the load in this case, then the corresponding quantities at the supports are easily obtainable. Separating the two portions of the beam as in Fig. 7, and applying the results of (5) above, we obtain on simplifying :

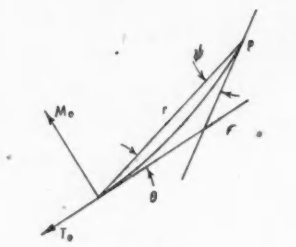


Fig. 3

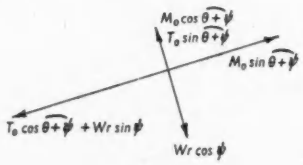


Fig. 4

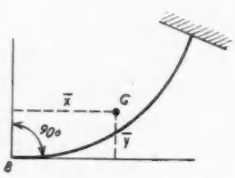


Fig. 5

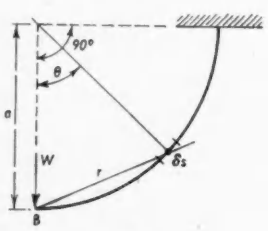


Fig. 6

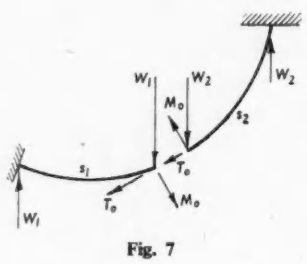


Fig. 7

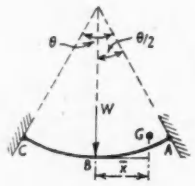


Fig. 8

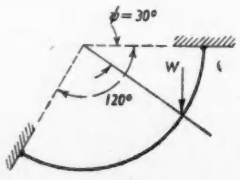


Fig. 9

from (5 ii),

$$M_0 = \frac{W_1 \cdot s_1 \cdot \bar{x}_1 + W_2 \cdot s_2 \cdot \bar{x}_2}{s_1 + s_2} \quad . \quad . \quad . \quad (6i)$$

from (5 iii),

$$T_0 = \frac{W_1 s_1 \bar{y}_1 - W_2 s_2 \bar{y}_2}{s_1 + s_2}, \text{ and} \quad . \quad (6ii)$$

from (5 i),

$$W_1 J_1 - M_0 s_1 \bar{x}_1 = W_2 J_2 - M_0 s_2 \bar{x}_2 \quad . \quad (6iii)$$

From (6 i) and (6 iii) we find,

$$\frac{W_1}{W_2} = \frac{(s_1+s_2) \cdot J_2 + s_2\bar{x}_2(s_1\bar{x}_1 - s_2\bar{x}_2)}{(s_1+s_2) \cdot J_1 + s_1\bar{x}_1(s_2\bar{x}_2 - s_1\bar{x}_1)} \quad . \quad (6iv)$$

For any symmetrical member AB, loaded at its mid-point B (see Fig. 8), from considerations of symmetry we see immediately that,

$$M_0 = \frac{W}{2} \cdot \bar{x} \text{ and } T_0 = 0.$$

(i) if ABC is semi-circular,

$M_0 = 0 \cdot 186 \cdot WR$ the exact value if Castigliano's Theorem is applied exactly.

(ii) If ABC is circular with $\theta = 120$ deg. and W acts such that $\phi = 30$ deg. (Fig. 9), we proceed first by using (6 iv) to find $\frac{W_1}{W_2}$. The relevant values are ;

$$s_1 + s_2 = 2 \cdot 09a ;$$

for

$$AB : J_1 = 0 \cdot 047 \cdot a^3 ; \; s_1\bar{x}_1 = 0 \cdot 132\, a^2 ;$$
$$s_1\bar{y}_1 = 0 \cdot 0236\, a^2.$$

and for

$$BC : J_2 = 1 \cdot 14 \cdot a^3 ; \; s_2\bar{x}_2 = a^2 ; \; s_2\bar{y}_2 = 0 \cdot 571a^2.$$

Thus

$$\frac{W_1}{W_2} = 5 \cdot 86 \text{ and } W_1 = 0 \cdot 856\, W.$$

Then $T_0 = 0 \cdot 030 \cdot WR$ and $M_0 = 0 \cdot 123 \cdot WR$. These values are in almost exact agreement with those given by A. J. S. Pippard in *Studies in Elastic Structures*, page 212, for $\gamma = 1$.

The simplicity of the results in (5) and (6) may commend them to designers, since by them they may easily obtain graphical results. The especial value of these expressions lies in their applicability to girders of unusual (i.e. non-circular) plan-form.

Tube Cleaning with Flame Equipment.—A method of cleaning the insides of tubes by the use of flame equipment was introduced on maintenance work carried out recently by the Prince Regent Tar Company. The tubes involved were those for stills used in the coal tar distillation process. In service these tubes become fouled by deposits of bitumen and normally cleaning is a tedious job undertaken with a mechanical drill and scraper. The new method was tried out with complete success, and is stated to have reduced cleaning time from as much as one day to thirty minutes. The still tubes were of cast iron and 15ft in length and 2in bore. The apparatus used was an adaptation of a British Oxygen flame cleaning equipment fitted with a simple burner with integral fins. These fins, besides spacing the burner from the wall of the tube, acted to some extent as scrapers, and the finned burner fitted into the bore so that the whole length of a tube could be traversed. In the initial attempts to burn out the residue too much heat was applied to the casting, but it was noted that at one stage of the proceedings the gummy bitumen turned into a form of powdery coke, which was easily removed by scraping. As a result of this experience a stainless steel burner was constructed, which had only a few $\frac{1}{16}$in holes drilled into it for gas nozzles, and these were sufficient to bring about the required conditions. The assembly was attached to an ordinary piece of oxygen lance tubing through which the gases were supplied, and it was then possible to push the assembly progressively through all the obstructions.

Extensions at the Works of the Power-Gas Corporation, Ltd.

Extensions completed at the new South Works of The Power-Gas Corporation, Ltd., have more than doubled the floor space available for the production of large vessels and plant for the gas, oil, chemical, iron and steel industries. As part of this works development scheme the firm designed and built a new 1100-ton hydraulic press and a 24ft by 50ft lathe to its own particular requirements.

DURING a recent visit to Stockton-on-Tees we had an opportunity to see the extensions completed a few months ago in the second stage of the development programme of the new South Works of The Power-Gas Corporation, Ltd., and Ashmore, Benson, Pease and Co. We also saw in operation two machines of particular interest which were designed and built by the firm for its own use in the new works. Under the extension programme two new fabrication bays have been added to the main building and a large, new heavy machine shop has been built to increase the works productive area by 65 per cent to some 230,000 square feet. The plant capacity now available is designed to make possible the manufacture of the largest types of vessels and equipment which are likely to be required in the foreseeable future in the gas, oil, chemical, iron and steel and other industries. The equipment installed is designed for use in fabrication to the highest standards of a wide range of materials, including mild, stainless and low alloy steels, nickel, "Inconel," "Monel," &c.

The firm acquired a site of about 100 acres some years ago for this new works, and when first opened in 1951 it consisted of a main block of four transverse bays each 250ft long by 85ft wide, with a longitudinal bay at each end 340ft long by 65ft wide. To this original block there have now been added two transverse bays of similar size, and the longitudinal bays have been extended to a length of 512ft. The transverse bays are 30ft high to the crane rails and the longitudinal bays have a height of 50ft to their crane rails. In addition to the normal road access, rail access has been provided into one end of each longitudinal bay and a rail track extends across the full depth of the shop down the centre of the transverse bays.

In such a works as this, where very large and heavy parts are in constant production and often have to be transferred from point to point with the least possible interference with other work in progress, the availability of adequate lifting facilities is of particular importance. For this reason close attention was given to handling problems which might arise in the future in the initial design of the buildings and the overhead crane installations. Each of the transverse bays is served by two overhead cranes of 10-tons, 15-tons or 20-tons capacity in accordance with the class of work for which it is laid out, and supplementary 1-ton or 2-ton radial jib cranes serve individual machines and working stations where heavy handling is entailed. One of the longitudinal bays has a 10-ton and a 20-ton overhead crane, whilst the other, where the heavier and larger classes of work are generally handled, has a 10-ton and a 50-ton crane installed. The higher level cranes in the longitudinal bays are, in addition to their normal duties, used to facilitate the transfer of work between the transverse bays. For this purpose the rail gantries of the cranes in the transverse bays are cantilevered to extend some 20ft out into the longitudinal bays, and work can be transferred directly from one set of cranes to the other for transport to other parts of the building and without need for intermediate handling on the floor. The photograph we reproduce as Fig. 1 clearly shows one of the transverse bay gantry extensions.

As part of the programme, the main stockyard at one end of the building has been lengthened to 800ft and it is now served by two 10-ton cranes on a 30ft high gantry along its full length. At present materials are transported from this yard into the main building by 20-ton electric rail bogies running into the ends of the longitudinal bays, but provision has been made for the extension of the main shop crane gantries out over the ends of the yard at some future date. With this arrangement it will be possible to transfer plate, &c., from the yard by the high-level cranes directly to those of the transverse bays without need for intermediate handling from the bogies.

The general layout of the plant is such that all plate preparation is carried out in two transverse bays and the adjacent parts of the longitudinal bays at the stockyard end of the building. In these sections a comprehensive range of plate preparation plant, including shearing machines, guillotines, plate edge planers, radial drills, bending rolls, profile flame cutting machines, &c., have been installed. From these sections the parts are transferred to the third, adjoining, bay in the centre of the building or to one of the two new bays at the far end where the main assembly work is carried out. Each of these constructional bays has a grid floor for welding and is equipped with manipulators capable of handling work weighing up to 6 tons. In order to keep the working area in these bays as free as possible of fixed equipment the 300A-400A welding transformers generally used are mounted on platforms high above the floor level on a number of the columns of the crane gantries. Panels, at floor level, on these columns in addition to possessing tapping points for the welding leads, also include connections to the oxygen, acetylene, compressed air and water supplied by a mains system to all parts of the shop. One of the service columns with its overhead transformers and service panel can clearly be seen in Fig. 1.

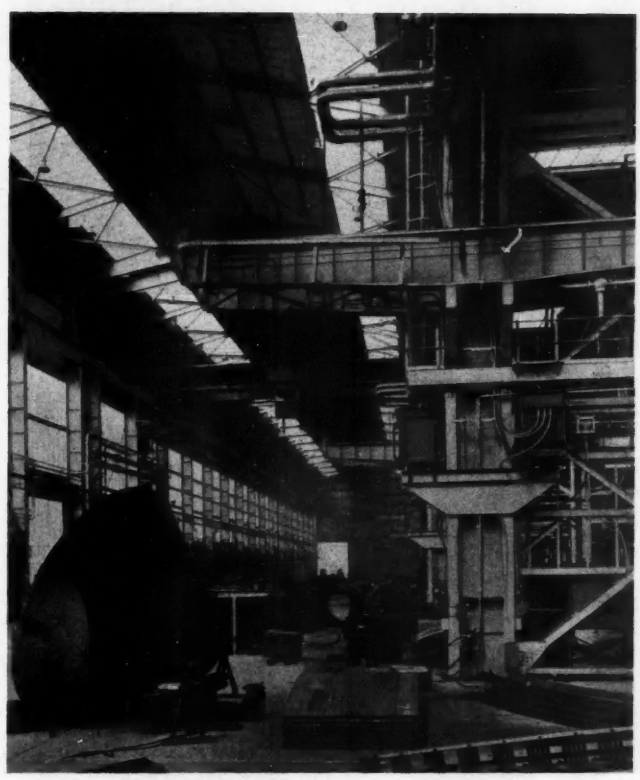


Fig. 1—Cantilevered extension of transverse bay low-level crane gantries into high-level longitudinal bay

A heavy pressing and large work assembling bay is situated between the central welding bay and the two new bays, and in this bay there was recently placed in service a new 1100-ton upstroking press of the firm's own design and construction. This four-column press was specially designed to comply with the particular requirements of the class of work handled, and, with the plate furnace which serves it, can be seen in the photograph we reproduce in Fig. 2. The general construction of the press itself is shown in the drawing, Fig. 6. Its three main tables, which weigh between 40 tons and 50 tons each, are of fabricated plate construction throughout and were made in the works.

The press has been installed in a pit some 16ft deep and is supported from a deep ledge in the pit by the fixed table on which are assembled the hydraulic operating cylinders. The working surface of the moving table when it is in its lowest position is at floor level, and work is pulled on and off the table by a winch at one side. Four 11in diameter columns anchored in the fixed table pass through large bushes in the corners of the moving table and support the top table on heavy screwed sleeves. Between the columns there is a clear working space of 15ft. by 8ft, and through the screwed sleeves on the columns the height of the top table can be adjusted to give a daylight from 4ft up to 11ft maximum.

The press has three 18in diameter main rams each with a stroke of 5ft. The central ram can be used alone to impart a load of 330 tons through the moving table; the two outer main rams can be used together to give a load of 660 tons or all three rams can be operated in unison to give a load of 1020 tons. The central ram incorporates a 12in diameter stripping ram which has a 7ft stroke and is capable of exerting a thrust of 152 tons. Two 8in diameter drawback rams are arranged one on each side of the central main ram and they are designed for a combined load of 130 tons.

When it is required to adjust the height of the top table the main central ram and stripping ram are extended to take its weight while the locking sleeves on the columns are screwed up or down to the required position. Supported in this way by the rams the table can be moved as required by use of the normal hydraulic system of the machine. In a machine of this kind it is frequently desirable to lock work in position on the table and for this purpose four vicing rams have been fitted. These rams are carried on slides on the top of the fixed table and project up through slots arranged at 90 deg. round the centre of the moving table. Through their slides the rams have a range of adjustment along the slots so that they can be positioned from 2ft 10in up to 5ft 6in from the centre of the table. Each vicing ram has a stroke of 4ft 6in and exerts a locking load of 152 tons.

The hydraulic system of the press is supplied with oil at 3000 lb per square inch by three 50 h.p. motor-driven rotary plunger pumps running at a constant speed of 1500 r.p.m. These pumps are pressure controlled and are designed to auto-

EXTENSIONS AT WORKS OF POWER-GAS CORPORATION, LTD.

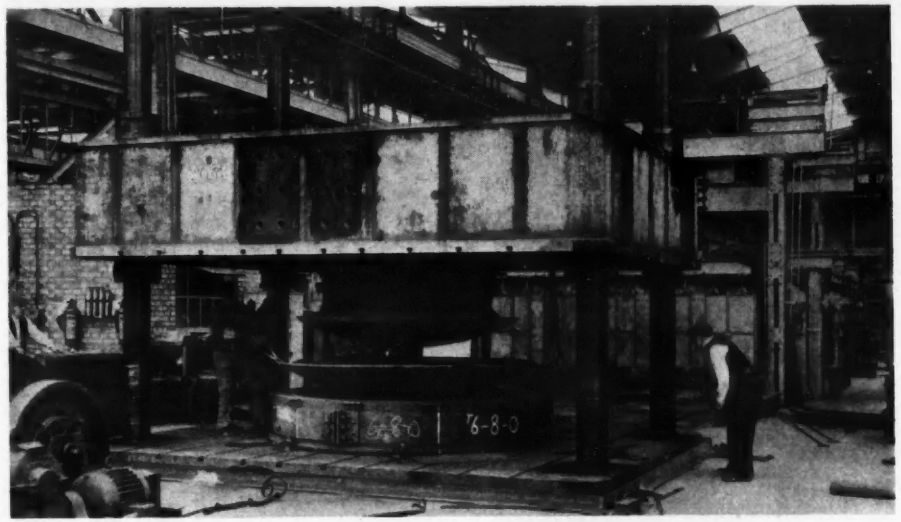


Fig. 2—1100-ton upstroking hydraulic press engaged in hot pressing dished ends

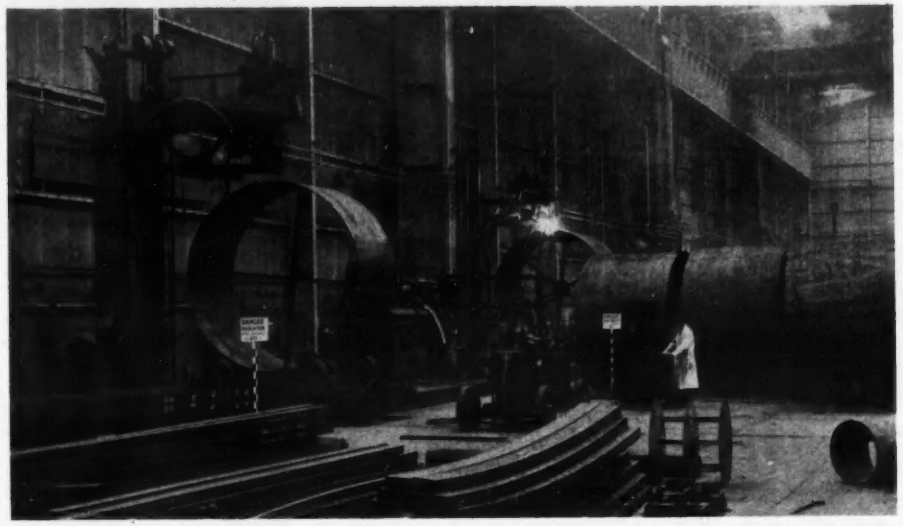


Fig. 3—"Fusarc" continuous welding set in heavy assembly bay. Vessels up to 13ft 6in diameter and 160ft long can be built in this bay

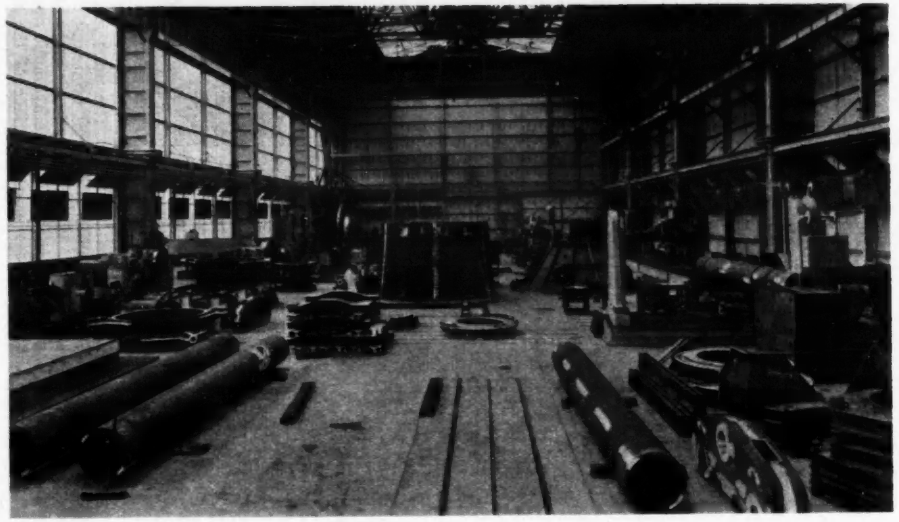


Fig. 4—New heavy machine shop

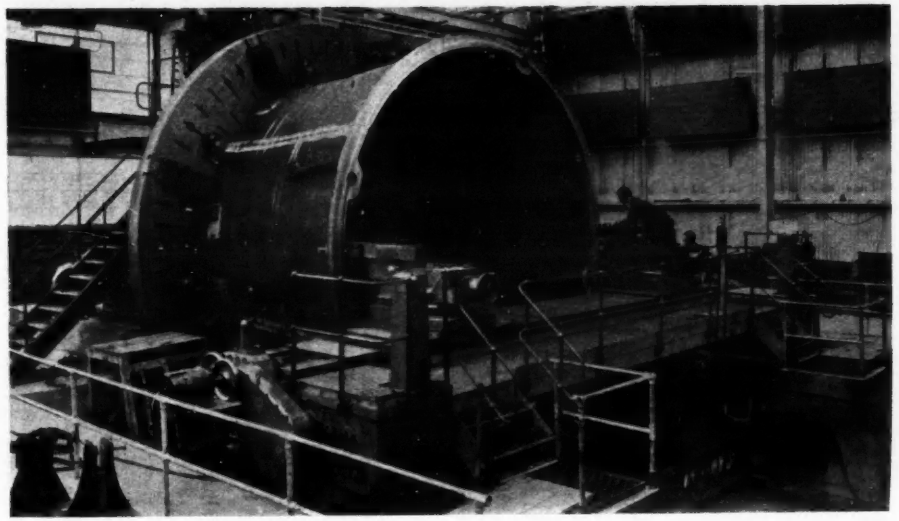


Fig. 5—24ft by 50ft lathe machining a blast-furnace hopper of 19ft diameter and 11ft 2in deep

matically maintain a delivery of fluid in accordance with the demands of the press and the number of rams in service. The press is operated by four main pilot-operated control valves from an adjoining cabinet and its maximum ram speeds are as follows : three main rams 0·5in per second; two drawback rams 3·5in per second ; four vicing rams 2in per second ; and the stripping ram 3in per second.

Particularly long cylindrical vessels are welded and the heaviest plant is assembled in the longitudinal bay, equipped with the 50-ton crane, which is illustrated in Fig. 3. Two Fusarc continuous welding sets are mounted on columns against the wall of this bay and four sets of power-operated work supporting and rotating bogies can be positioned on tracks in front of these welding sets. The height of the welding heads can be adjusted on their columns to permit the welding of vessels up to 13ft 6in diameter and the bogies can be spaced to handle such vessels up to 160ft long. In the illustration can be seen one of the firm's mobile X-ray sets in use checking a seam in a section of pressure vessel welded on a Fusarc machine, whilst a similar section is being welded on the other machine at the rear.

The new heavy machine shop building which is some 250ft long by 112ft wide can be seen in Fig. 4, and in its construction provision is made for increasing its length or the addition of further bays along one side. As the production will entail the transfer of heavy and often very large work between machines the crane rails have been set at a height of 50ft so that such transfers can be made without need for disturbing work in hand on intervening machines or in course of assembly. The lighter work is handled by a 15-ton overhead crane and the heavier work by a 50-ton crane. Materials from the stockyard and semi-finished parts from the adjacent constructional building are brought into one end of the shop by a 20-ton electric rail bogie.

Amongst the principal equipment at present installed along the sides of the shop are an open side Butler planer with a 22ft table capable of handling work up to 6ft wide by 6ft high and weighing 35 tons ; a 6in and a 5in horizontal boring machine; a 4in horizontal drilling machine; a 10ft vertical boring mill ; a 36in centre lathe taking 16ft between centres ; a 12ft radial drill ; and a new 24ft by 50ft lathe of interest which is illustrated in Fig. 5.

The firm decided to instal a new lathe of particularly large capacity some time ago in order to relieve the pressure on the existing turning, boring, planing and milling machines. At that time it was not possible to obtain reasonably quick delivery of special machines incorporating all its requirements, so the firm decided to design and build the machine in its own works. As finally constructed the lathe is capable of swinging work up to 34ft diameter up to a 2ft depth from the faceplate ; 24ft diameter between 29ft 6in centres, or 11ft 9in diameter between 50ft centres. Work weighing up to 30 tons can be carried by the faceplate providing its centre of gravity is not more than 7ft from the plate and the maximum load which can be handled between centres is between 50 tons and 60 tons. Machining can be performed up to some 12ft from the faceplate without the use of centre support for the work.

The general construction of the lathe can be seen in the accompanying drawing and illustrations. Its foundation structure of heavily reinforced concrete is essentially a part of the machine, and to avoid settlement and distortion this raft structure is supported on concrete piles 35ft deep. As can be seen, the main headstock is set at general floor level and the 23ft diameter face plate is overhung at one end of a pit some 31ft long. Two sets of rail tracks bedded in the floor along the length of the pit provide accurate ways on which are set the support stools for a rigid cast iron gantry structure carrying the tool saddles (Fig. 8). These support stools can be arranged transversely or longitudinally on the tracks in the pit to position the gantry for facing or longitudinal machining. The rails have notches machined in them for locating the support stool bases and similar locating points and keys are provided for positioning the stools and the gantry correctly. At the far side of the pit similar sets of rails are laid at floor level and aligned with the headstock spindle to provide ways for the tailstock. A second set of rails at the side of the tailstock ways are used to carry the tool slide gantry when the work being machined extends beyond the length of the pit.

The whole of the electrical system for the machine is fed from the works supply at 415V, three-phase, 50 c/s, and the power circuits, including the main driving motor for the Ward Leonard set, together with various other machines, operate on this supply. All the control circuits for the machine are fed at 220V d.c., supplied by a suitable transformer and rectifier unit.

The headstock casting carries the main spindle in two roller bearings of 25in and 20in diameter

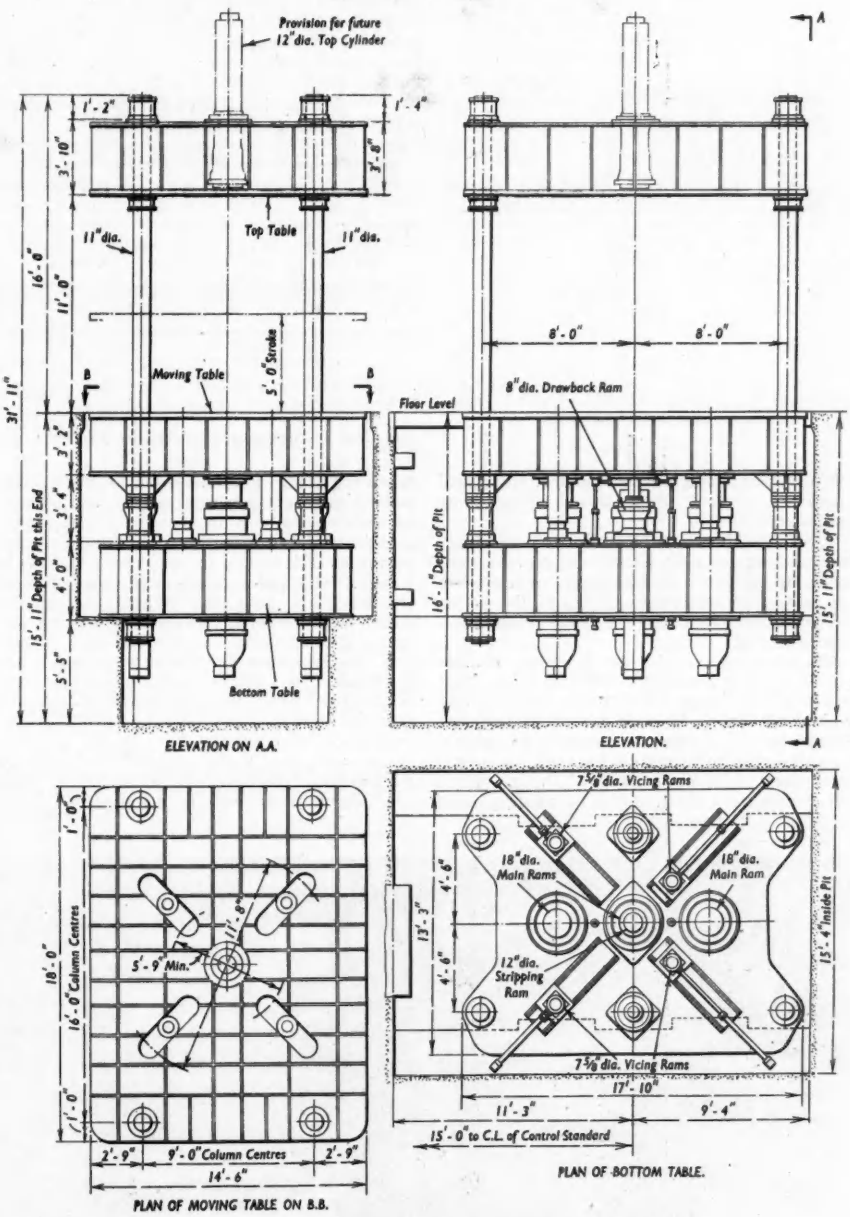


Fig. 6—Arrangement of 1100-ton upstroking hydraulic press

respectively, and these bearings were specially designed by Cooper Roller Bearings Company, Ltd. The front bearing, which has a diametrical clearance of 0·001in, is designed for a radial load of 150 tons and a maximum speed of 18 r.p.m. Preloaded angular contact roller bearings are fitted to take an axial thrust of 15 tons. The " Meehanite " spindle is bored throughout its length to take a pull rod which can be used to support work when setting up, and it has a 6ft diameter head on to which the face plate is shrunk. This 23ft diameter face plate, which is also made of " Meehanite," weighs some 50 tons and was machined in position on the lathe itself. It is slotted for work mounting purposes and is provided with eight sets of adjustable dogs for chucking work.

The main drive is mounted on a fabricated base which forms an integral part of the main foundations, and incorporates ducts through which the cooling air is supplied to the motors from a fan at the rear. The drive consists of two d.c. variable-speed, 40/1600 r.p.m., 60 h.p., 460V, shunt wound, separately excited motors, driving spur reduction gearing. Final drive from the reduction gearboxes is transmitted through two pinions which engage with a 14ft diameter spur wheel fitted on to the rear of the face plate. The fields for the main motors and the Ward Leonard generator are supplied from a 4kW exciter set and the field voltage for these machines is controlled by means of a motorised regulator which is driven by a constant-speed, squirrel-cage, geared motor to raise or lower speed as required under hand or automatic control.

Two means of speed control of the face plate are provided—(*a*) by the operator directly through operation of speed increasing or decreasing push buttons, or (*b*) automatically, i.e. so that the face plate speed is automatically varied inversely as the diameter of the cut, thus maintaining a constant cutting speed across the face of the work. A 5 h.p. barring motor is provided to provide an alternative drive in place of the main

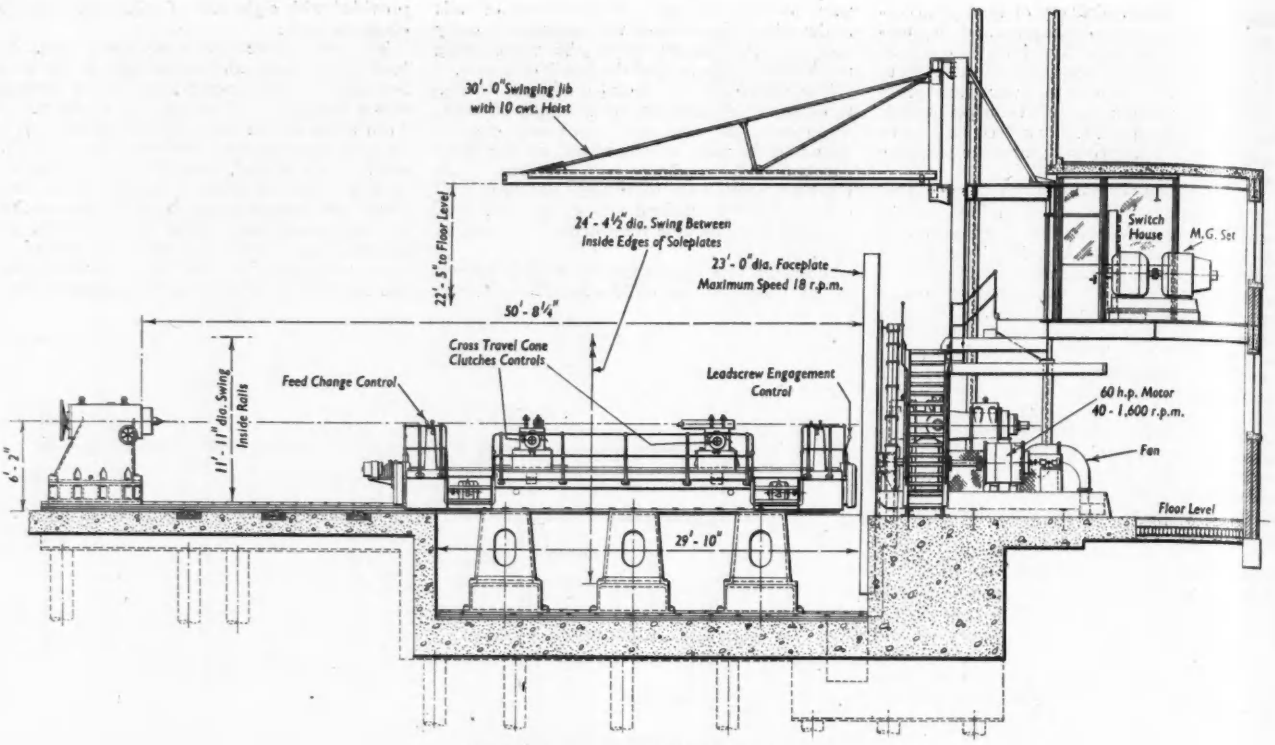


Fig. 7—Arrangement of 24ft by 50ft lathe

motors when setting up the machine. Electrical interlocks prevent these drives from being used together.

A solenoid brake mounted between the main bearings engages a 4ft diameter drum and automatically brings the spindle gently to rest when the motors are de-energised. It can also be set to give continuous braking when doing interrupted cutting.

The gantry (Fig. 8) on which the tool saddles are mounted is a separate unit and it was built to the firm's design by Urquhart Lindsay and Robertson Orchar, Ltd. Its bed is 30ft long and carries two independent compound saddles. In addition to the normal cutting tools for turning work these saddles are designed for the fitting of independent drilling, milling or grinding heads when required. The feed drive for both longitudinal travel along the gantry and cross traverse of each saddle is by means of a 4 h.p. motor, and the saddle and top slide feed rates are selected by means of levers on pillars at each end of the gantry. The feed control circuit is so arranged that each of the saddle motors can operate either as a normal a.c. motor for quick traverse or on a synchronous tie between main spindle and the leadscrew for constant cutting speed purposes. Two magnetic clutches are provided so that these drives may be disconnected without stopping the machine. Screw cutting can be performed by operation both of the top tool slides and the main saddles and through twelve-speed gearboxes the screw-cutting range available is from 0·004in to 8in pitch. From any working point on the gantry the operator of the machine maintains full control through push-button pendants, and a control desk situated near the lathe is used for presetting speeds, reversing the main drive, &c. Large dials on this cabinet, which are clearly visible to the operator, show the face plate speed in revolutions per minute and the cutting speed in feet per minute.

For segmental cutting purposes, or where on account of some obstruction a complete revolution cannot be obtained, the spindle can be oscillated through a portion of a revolution to give a planer action. For longitudinal slotting purposes on particularly long work the power traverse of the saddles along the gantry can be used if necessary.

The gantry is fitted with a walkway and stairways for access, and hinged walkways forming chip guards are attached to each saddle to give access to the tools and protect the gantry surfaces. All the slides are protected by felt seals, and are lubricated by grease gun.

The tailstock is of very rigid construction and its live barrel is mounted on S.K.F. self-aligning roller bearings. It is carried on accurately aligned cast iron vee rails and provided with a set-over device which can be used for precision setting purposes. The normal accuracy of alignment is stated to be 0·010in in 50ft.

The 50-ton shop crane which handles work on and off the machine is also used for repositioning the gantry and its pedestals when necessary. For handling tools and lighter component parts a 10 cwt electric hoist is mounted on a 30ft swinging jib above the headstock of the machine. We mentioned earlier that the lathe is designed to handle work weighing up to 30 tons on the face plate providing the centre of gravity is not more than 7ft from the plate. As a matter of interest it should be pointed out that the blast-furnace hopper shown on the machine in Fig. 5 weighed some 44 tons and was 19ft 2in diameter by 11ft 2in deep. This load was well in excess of the designed capacity of the machine, and it was machined for test purposes without the use of a centre support which would be used under normal circumstances for work of this weight and depth.

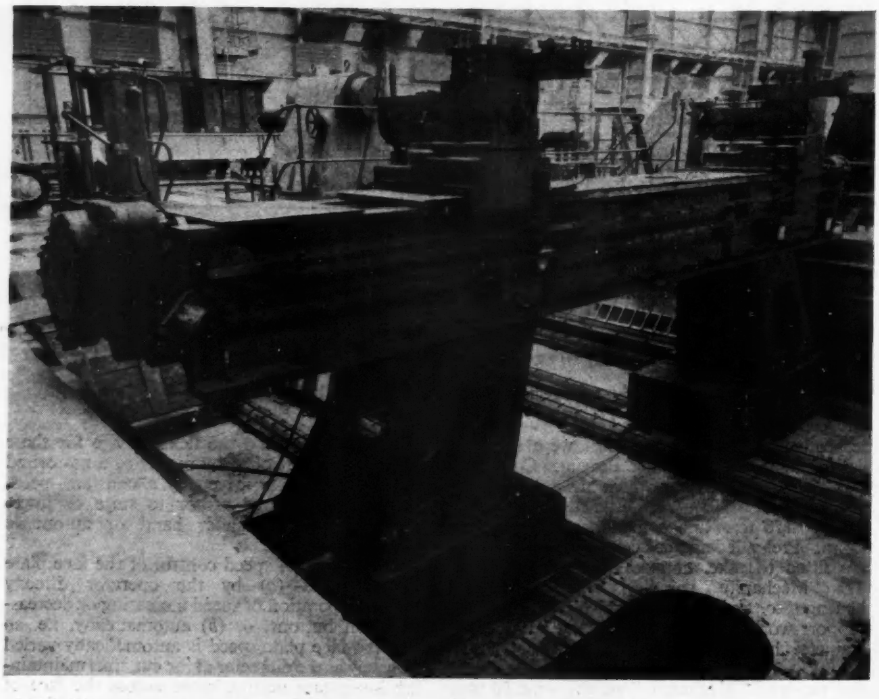


Fig. 8—Lathe with its middle gantry set transversely across pit for facing work

DUTCH OILFIELDS.—A new oilfield is now in production at Rijswijk, a suburb of The Hague, Holland, and consists of eight wells, of which five are producing oil at the rate of 30,000 tons per annum. The Schoonebeek oilfield in the north-east part of the country has an annual current production of 920,000 tons.

Computer-Controlled Machine Tools

By D. T. N. WILLIAMSON*

This paper was presented at the conference on "The Automatic Factory—What does it Mean" organised by the Institution of Production Engineers and held at Margate in June. It deals with the development of the electronic digital computer, and its application to the automatic control of machine tools.

THE electronic digital computer has in recent years been the subject of great development as a high-speed calculator of immense value as a mathematical tool in scientific and engineering research and development. Its application to commerce has so far been limited to wages and tax calculations and actuarial problems, in which field it has been shown to be capable of effecting large savings.

The promises for the future which these techniques render possible in the control of industrial processes, oil refineries, chemical plants, transport systems and so on, are so immense that it is easy to be carried away on a wave of Wellsian enthusiasm. These developments, although they will be more rapid than sometimes thought, are not yet with us, and considerable improvements in technique will be necessary before their introduction.

Another application of digital computers, which can make a direct contribution to the efficiency of small-quantity productions in the engineering industry, is the control of metal-cutting processes, giving rise to universal machine tools in which the setting-up time is so short that efficient automatic production of small batches and even single components can be achieved. This development has now reached the stage at which prototypes are being tested, and a considerable number of machines will be put into workshop service during 1956. It makes possible major advances in the engineering industry during the next five or ten years, without which the present rate of expansion cannot be continued, because of shortage of skilled manpower.

THE PROBLEM OF BATCH PRODUCTION

The techniques of mass-production, although subject to a constant process of change and improvement, are now well established and universally accepted. They call for a high initial capital outlay, but provided the production quantities are large the efficiency of these methods is not in doubt.

In several important industries the production quantities are so low that the use of mass production techniques becomes very inefficient. In certain cases, however, the use of jigs, fixtures and templates is the only available means of doing the job, because interchangeability of components is still required, and their amortisation represents a major part of the cost of the article.

The aircraft industry is a typical case. Here it is quite rare for production quantities to exceed 100 per annum. Although duplication within each aircraft may increase the total quantity of a particular component, the numbers are still far too low to render mass production techniques efficient and cheap. In general, therefore, the tools and components require a disproportionate amount of skilled work, and the supply of skilled craftsmen is by no means equal to the present demand and appears to be diminishing. Difficulties of this type occur in every progressive industry where prototype models have to be made, usually in quantities of less than ten.

A similar situation occurs during the tooling-up period when mass production of an article is being undertaken. Here many tools, some very large and of exceedingly complex shapes which have to be produced to a very high degree of accuracy, require to be cut from the solid, a very costly and time-consuming process which delays the start of production very considerably, and, of course, contributes to the final cost of the article.

COMPUTER-CONTROLLED MACHINES

In order to contribute to the solution of this problem, which was particularly acute in their own works, the Ferranti Research Laboratories in Edinburgh undertook a long-term development programme which commenced in July, 1952. From surveys undertaken at the outset, it was apparent that existing types of machines, although they could help considerably in some cases, did not go very far along the road to the economic manufacture of tools and prototypes in small quantities, and that a fresh approach to the problem was required.

It soon became obvious that the reason for the high cost of prototype manufacture was poor utilisation of the available skill. For instance, a man using a milling machine on a job similar to die-sinking cannot possibly think fast enough to utilise the machine at a level remotely near to its peak capability, and most of the manufacturing time is spent reading and interpreting drawings and transferring the data into the feeds of the machine, a process which is incredibly inefficient, involving as it does much redundancy, head-scratching and slow progress in order to avoid errors. The average feed rate, that is, the total length of cut divided by the production time, is exceptionally low, and even the actual feed rate, when cutting is in progress, rarely approaches the optimum for the material being machined because human reaction time is far too slow to allow accurate control at these speeds. Much time is spent in altering the position of the work or the set-up of the machine in order to machine contours such as radii, which cannot readily be specified in rectangular co-ordinates, but require the use of circular tables.

To improve this state of affairs, it was clear that the fundamental requirements were a reduction in machining time and the thinking time, the preservation or possible increase of skill in the form of high accuracy, and great flexibility so that one machine could tackle diverse problems. The problem in its broadest interpretation, therefore, is one of feeding information, in the simplest possible form, about the work to be done, into a device which will interpret this information and produce from it the necessary tool movements, at the highest possible speed, in order to machine the article from a solid block or casting to the limits of accuracy required.

HOW THE SYSTEM WORKS

With modern techniques of computation and control such a process is entirely feasible. A system which has been developed can be divided into four stages :

(1) The transference of the drawing information along with machining data to a standard planning sheet.

(2) The coding of this planning sheet on to punched paper tape.

(3) The production from this paper tape of a recorded magnetic tape by means of a digital computer .

(4) The use of this magnetic tape to control the machining operation.

The article is designed and a drawing or sketch made in the usual manner, the only departure from normal practice being in the precise method of dimensioning, where all dimensions are given from a datum and include the co-ordinates of all points of change, i.e. where a straight line joins a radius and so on. Due to this, the designer has considerably greater scope in the selection of his contours than with normal machining methods.

Stage 1 : *Planning.*—This drawing goes to a planning engineer, whose function is to know the capabilities of the machine and how the article should be machined. He inserts the metric information of the drawing in the correct sequence in a standardised planning sheet, interspersing the drawing data with information, which he himself supplies, regarding the cutter radius which he has selected, along with the feed rate, rotational speed and other machining data. In order that the system should have maximum possible utility and give the greatest freedom from human errors, the information which it requires to be given is kept down to its simplest possible form, consisting basically of the co-ordinates of the points of change of the surface of the work and a specification of the curve between pairs of co-ordinates.

Thus, to take a hypothetical example, Fig. 1 shows a simple two-dimensional cam, the planning sheet for which would be as follows :—

Cutter diameter = d. Feed rate = F.

Co-ordinates of datum (x_1y_1).

Type of curve	Co-ordinates of change points	Co-ordinates of pole of curve
Line	x_2y_2	
Circle	x_3y_3	x_4y_4
Line	x_5y_5	
Line	x_1y_1	

No co-ordinate information need be given between points which can be specified by an equation or parameters of a curve, such as the centre and radius of a circle. This example shows

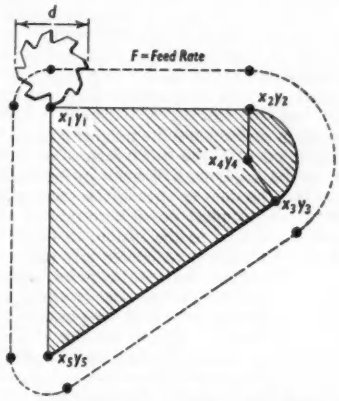


Fig. 1—Simple example showing the dimensioning and planning technique used

a contour in two dimensions but there is, of course, no difficulty in extending this to three dimensions.

Stage 2. *Paper Tape.*—This planning sheet goes to a typist who transfers the data to the form of punched tape by means of a teleprinter.

Stage 3. *The Computer.*—The short length of punched paper tape now contains the minimum basic amount of information required to produce the component, but in order that a component can be produced from it this information has to be extended and the gaps between co-ordinate points filled in. This is done by the digital computer, which accepts the basic information and, controlled by the equation of the curves, calculates continuously the required path of the centre of the cutting tool in x, y and z co-ordinates. The output in each co-ordinate is in the form of a train of pulses, each pulse corresponding to a very small unit of movement, usually one ten-thousandth of an inch. Thus the total number of pulses in each channel determines the distance moved in that co-ordinate, and the pulse rate determinates the speed of movement or feed rate. These pulses are synchronised in the x, y and z channels in such a manner that a tool controlled by them follows a path corresponding to the calculated track within one ten-thousandth of an inch. These pulses are recorded on three separate channels on magnetic tape and, simultaneously, on a fourth channel, control information, appertaining to functions of the machine other than slide movements, is recorded.

The types of curve which may be covered are limited only by the complexity of the computer, but for normal engineering uses it is expected that a computer with built-in programmes, which will contour any curve which may be specified by a second degree equation, including circles, ellipses, parabolæ and hyperbolæ, will be satisfactory. More complex shapes which occur only rarely can be approximated with sufficient accuracy by a combination of such curves. In the aircraft industry, although the surface of an aerofoil may be specified basically by an equation, in practice this surface is frequently modified slightly by wind tunnel tests and it then becomes difficult to specify except as a series of ordinates. Such surfaces are best produced by means of a computer which can utilise ordinates and produce a smooth curve through them.

A modern digital computer can handle information at a rate very much higher than the highest feed rate which can be used in practice.

* Ferranti, Ltd., control systems development department.

Advantage is taken of this fact to record the pulses on magnetic tape moving at ten times the normal play-back speed. This is of considerable importance, as it means that one computer can record tapes for a large number of machines. Its paper tape input can be prepared by a number of planners without occupying computer time, and the number of machines controlled depends only on computer speed and the average duplication rate.

With a computer-speed/machining-speed ratio of ten and an average duplication rate of five, varying from unity for single prototypes and tools to, say, ten or twenty for component parts, a single computer could supply fifty machines with recorded tapes. In addition, a tape link allows the amount of electronic equipment in the workshop to be reduced to a minimum.

In work of this character errors are liable to occur at various stages in the preparation of the data which is coded on the paper tape, the actual coding itself, the reading of the paper tape, the computation process and the magnetic recording. It is expected that the most serious source of errors will be the human element in the systems, even though the data to specify the job has been reduced to its simplest possible terms. Various checks are included in the system in order that errors may be discovered before any machining is done. The data, up to the point where it emerges as a coded paper tape, is checked by the techniques normally used in punched card accounting systems, which involve basically duplicating the work and comparing the results. In addition, a further check of the whole system right up to the magnetic tape is possible if the work is programmed in closed loops, that is, the tool is arranged to touch its previous path several times during the operation. This is always possible, even though the tool may be lifted away from the work for part of the time where no cut is required. At the point where the loop should close a marker pulse is recorded on the magnetic tape and the pulses in the x, y and z channels counted immediately after recording in order to see that they summate to zero at these points. If a tape passes this test it is reasonably certain that it is correct and when put on the machine will produce accurate work.

Stage 4. *The Controlled Machine.*—A digital computer can produce control information of the kind outlined above to any desired degree of accuracy, but this is useless unless the measurement and control system of the machine slide has a similar degree of accuracy.

It was clear at the outset of the programme that no great reliance could be placed on the use of a lead screw as a method of measurement, although this is normally the only measuring agent fitted to machines. Problems of backlash and the compressibility of the oil film render such a system useless where machining must be done to close tolerance by dead reckoning.

The ideal method would be to measure the actual surface of the work as it was being cut. This is technically feasible for turned articles where the surface is available at a different position from the cutting position a very short time after it is cut, but it is not possible to do this in milling because the work is obscured by the cutter. The best that can be achieved is to measure the movement of the surface of the table on which the work is fixed, relative to the main body of the machine. With this method the machine and tool deflection will cause an error, which can be reduced to a suitably low value by designing the machine correctly. In general, the principle which has been adopted is that the measurement system should be rather better than the accuracy to which the machine can normally work; thus any machine, taken as designed, is used to its maximum capability.

The Ferranti Optical Grating Measuring System

Various mechanical methods of measurement which produce a digital electrical output suitable for automatic control are possible. Most are based on the rack and pinion principle and are troublesome where high accuracies have to be achieved, because of factors such as the presence of dust, variability of oil film thickness, tooth ripple and so on. A method of measurement with none of these disadvantages has been devised, utilising an optical grating with a specified number of lines per inch. This method has the advantage that the accuracy is unaffected by wear and can be made as high as desired. For instance, with a grating of 25,000 lines per inch it would be possible to discriminate between a few millionths of an inch provided, of course, that attention was paid to all the other factors which affect such fine measurement, such as temperature, vibration and slide design. By the use of gratings with 5000 lines per inch it is a simple matter to move

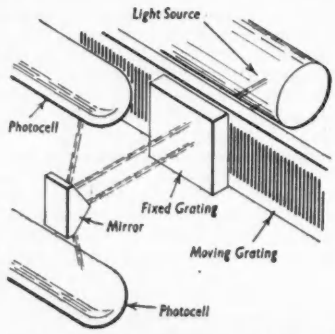


Fig. 2—Diagrammatic illustration of the Ferranti optical-grating measuring system

a slide consistently to an accuracy of one ten-thousandth of an inch, which is sufficient for all normal engineering processes and is better than the inherent cutting accuracy of most machines.

Both photographic and prismatic gratings can be used for this purpose, but prismatic gratings have definite advantages when the number of lines per inch exceeds about 1000. Such gratings have not hitherto been manufactured in sections sufficiently long to be utilised for measurement, but the Light Division of the National Physical Laboratory has, for some years, been developing a process for making large prismatic gratings for spectroscopic purposes, and these gratings have now been adapted for measurement.

The method of utilising the gratings for measurement is shown in Fig. 2. A suitable length of grating is attached to the machine table and a short length of the same grating attached to the other section of the slide, so that one grating traverses the other with the two surfaces almost in contact. If a beam of parallel light is projected through the pair of gratings and they are suitably aligned, the Moiré fringe pattern produced will modulate the light transmission when there is relative movement. One complete cycle of variation of intensity will occur for a movement equal to the pitch of the grating. By arranging two photo cells so that the phase of this light variation is different in each, a two-phase electrical system can be formed, the total number of cycles of which represent the distance moved, the frequency represents the velocity and the direction of phase rotation reveals the direction of movement of the slide. It is a simple matter to obtain from this system two or more discrete electrical pulses per grating line.

The Digital Servo-Mechanism

Fig. 3 shows a block diagram outlining the servo-mechanism which translates the pulse trains from the magnetic control tape reader into accurate slide movements. Considering one channel, the control pulses are fed to a direction interpreter and, according to the direction they represent, are passed to a register. This is a reversible counter with a small storage capacity, producing an electrical output proportional to the magnitude and direction of its contents. The control pulse train is also fed to a "rate meter," which produces an electrical output proportional to its repetition frequency and direction. These combined outputs actuate a high-performance secondary servo-mechanism to drive the table. Positional feedback from the table is obtained from a grating and direction discriminator, and the pulses from this are used to cancel the command pulses in the register. The system is so arranged that the error between the command pulses and the positional feedback from the table does not exceed one pulse, giving a maximum error in slide position of half a grating line.

In order to avoid an accidental overload of the servo-mechanism which might produce an error, the computer is arranged to limit the maximum rate of change of command information to that which may be handled safely.

Operation of Computer-Controlled Machine Tools

Automatic control systems of this type must be engineered so that they are highly reliable and the occurrence of faults very infrequent. Circuit elements must be chosen which are known to be reliable. In the system described the most frequently occurring elements are carbon resistors and germanium diodes, and circuits have been designed round these elements in such a manner that the possibility of failure is minimised.

In industrial equipment of this degree of complexity it is of paramount importance to avoid circuits which have critical operating conditions or components. The use of automatic self-checking procedures is a worthwhile step, and it is beneficial to carry out a marginal testing procedure each day, by reducing the supply voltages whilst a standard checking programme is being handled. Any circuit elements which are on the verge of failure are likely to be shown up by this method. In spite of this, faults may occasionally occur and it is essential that they can be located and replaced rapidly to avoid any dislocation of production routine.

It is, of course, essential if a fault occurs in the control section of the equipment that the machine should cease to cut immediately, in order to avoid ruining the work. This can be done by arranging that the signals from the registers,

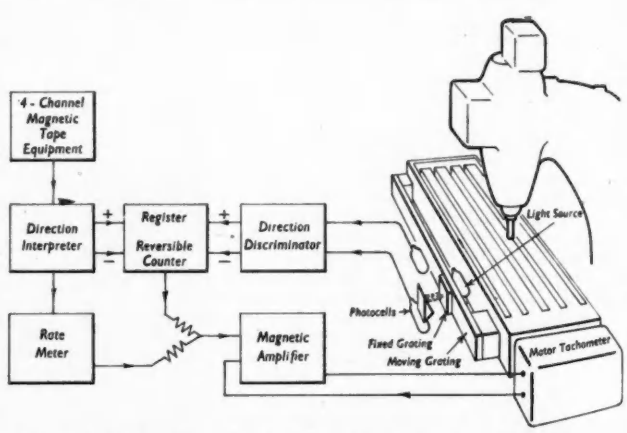


Fig. 3—Block diagram of digital machine-control servo-mechanism

which reveal all deviations between the demanded position and the actual position of the slides shut the machine down if the deviation exceeds a certain predetermined limit. This, in combination with two anti-coincidence counters covering the channels from the tape to the register and from the grating to the register, can give a complete check on the behaviour of the machine.

The systems described have been in partial operation for several months now. Preliminary results show that an overall accuracy of ±0·0005in should be achievable with good quality standard machine tools, which is sufficiently good for the majority of precision work. Higher accuracies are desirable for a limited number of applications, e.g., tool and die-

making, and aircraft scale models for wind tunnel testing.

The limit of accuracy of ±0·0005in on a standard milling machine is set, not by the control and measuring system, but by deviations from perfection in the machine tool itself and by the physical nature of the cutting process involved in milling. The cutting tool and the material being cut are both elastic, and deflections and deformations are produced by the cutting stresses, which, unless they can be predicted and allowed for, may introduce errors up to 0·001in. Where high accuracy is required in milling, the technique of a roughing and a finishing cut is used. This can be achieved simply by running the paper tape programme through the computer twice, first with a figure for cutter diameter, say, 0·010in larger than is actually being used, and then with a figure for cutter diameter differing from the actual value by an amount sufficient to allow for the likely elastic deformation based on previous experience.

The fundamentals of metal cutting are not at present well understood and much more work is necessary to establish the relationship between factors such as tool sharpness, peripheral and feed speeds, elasticity conditions and machining accuracy. Research into this problem has already been stimulated, and may be expected to gain impetus as the importance of automatic machine control for the future of industry is realised.

Although it is desirable to increase the accuracy of the milling process, especially for work in light alloys, the bulk of requirements for high accuracy call for a grinding process. Tools, dies and wind-tunnel models are generally made from hardened or very tough materials, for which grinding is the only satisfactory finishing method. In grinding, the relationship between the diameter of the grinding wheel and the finished size of the work is more accurately known, and work to finer limits is possible. Breakdown wear of the grinding wheel is a problem, but not a serious one if the final cut is restricted to a thousandth of an inch or so. Allowance can be made on the tape programme, if necessary, for resizing the wheel from time to time by a diamond trimmer.

Errors caused by imperfections of the machine tool are mainly due to slide inaccuracies and play, lack of rigidity, backlash in the drive system and friction. Under normal running conditions, the grating measuring system will provide accurate positional information which will enable the servo-mechanism to correct errors due to backlash and slide inaccuracies.

In order to assist the servo-mechanisms to deal with backlash the computer can be arranged, when a reversal of the slide is required, to set in one pulse in the reverse direction automatically and then wait for a fraction of a second to give the servo-mechanism time to cancel this pulse before proceeding with the rest of the train. Occasionally, the impact forces from the cutter teeth are sufficiently high to take control of the slide in the region of backlash and play, and the servo-mechanism is powerless to correct this, as the accelerations involved exceed its capabilities. This problem is, of course, more serious in milling than in grinding, where the force exerted by the grinding wheel is relatively small and uniform.

The design of machine tools has not changed radically for many years and is, in general, unsuitable for very accurate automatic control. Kinematic design is almost unknown and, as a result, machine slides are difficult and expensive to make and even more difficult to maintain in a good state of accuracy. The efficiency of a slide and drive system rarely exceeds 15 to 20 per cent, and hence a relatively high power is required to drive it. In the past this was of little consequence, as it merely necessitated a larger motor which was not proportionately expensive. In a controlled machine, however, this power has to be provided by a servo-mechanism, and is very much more expensive per horsepower than before. In addition, servo-mechanism performance inherently drops as the size is increased, so inefficiency is dearly bought.

The use of kinematic elements such as recirculating ball nut and leadscrew assemblies and bushings, spring-loaded to the level of the maximum loads to be encountered, can be made to give high efficiency and complete freedom from maintenance troubles combined with a degree of rigidity and lack of play and backlash unprecedented in machine design. Replacement of the conventional leadscrews of the prototype computer-controlled milling machine by recirculating ball nut pairs with special leadscrews, preloaded to the maximum table force of 500 lb, has been markedly successful. The transmission efficiency has been increased from 20 to 80 per cent, whilst the backlash has been reduced to less than 0·0001in. This performance will not be subject to deterioration due to wear.

Although the lines of approach to this problem of better machine design are fairly clear, a considerable amount of detailed work and fundametal research on the properties of materials is necessary before the design can be undertaken with complete confidence. The design of new kinematic elements, so that they may be produced in quantity and become as readily available as the ball-race is to-day, is one of the aims of this development programme. With these available, machine construction could become the assembly of standard elements, constructional difficulties and the need for working to fine tolerances

Fig. 4—Automatic setting co-ordinate drilling machine

would be greatly reduced, and the performance would be readily predictable. The advent of automatically controlled machines for very close tolerance machining presents a challenge to machine tool designers and manufacturers which is sure to lead to greatly improved standards of performance.

In addition to the application just described, in which the machine table is under the control of a magnetic tape at every instant in time, there is another important use of the grating measuring system in machines in which the table merely requires to be positioned, as distinct from being profiled. Jig borers, drilling machines, capstan and automatic lathes are machines of this type. Such applications are very much simpler than the one just described, as it is necessary only to set up a number, corresponding to the dimension, on an electronic counter and to cancel this number by the count from the grating measuring system. The setting-up can be done by hand or automatically by means of punched card or paper tape, and great speed and accuracy are obtainable by this means, particularly when a pattern of holes has to be drilled on a repetitive basis as with heat-exchanger plates, gear plates, &c. Fig. 4 shows an example of a controlled drilling machine.

The Economics of Computer-Controlled Machine Tool Operation.—To give an accurate general illustration of the saving in time and money and the very large increase in productivity made possible by these techniques is not easy. Two examples, which are typical of the gain in speed in tool-making, may be quoted.

A three-dimensional cam for a turbine blade miller taking three weeks to make by present methods can be planned, computed and machined in four hours, without the need for hand finishing.

A milled-block waveguide structure, which consists of a very accurate track, machined in a light-alloy block, with a mirror image of the track machined in another block, the two being placed together to form a complete waveguide assembly, employs a skilled machinist for two weeks using a conventional vertical milling machine with a rotating head. To plan, compute and machine both halves on a computer-controlled milling machine takes one hour, of which the actual machining time is thirty minutes, being limited, on the particular machine used, by the low cutter speed. With a high-speed routing head, the machining time could be reduced to ten minutes.

These are examples in which the "thinking time" forms the greater part of the total time of conventional machining, but they are typical of tool-making, die sinking and prototype manufacture, and in terms of time alone such examples form a bottleneck which can be ill-afforded in modern production. The immobilisation of plant and skilled manpower which it entails are very evident in the engineering industry to-day, in aircraft and engine manufacture, in tooling for mass production and in prototype manufacture. In such industries the use of these techniques forms the complete answer to the shortage of skilled machinists.

The introduction of computer-controlled machine tools is attractive on economic grounds alone. The cases cited above show a reduction in production time of 50 to 100 times. Such cases are frequent, but there are others in which the employment of special machines and training has already effected a reduction in operating redundancy, so that the production time might only be reducible by, say, ten times.

The saving in inspection time consequent upon the employment of machining methods of known and consistent accuracy will also be considerable and the extension of these techniques into the fields of setting-up and inspection gives scope for similar savings.

Future Developments

The development of computer-controlled machine tools so far outlined is a practical reality and will find increasing application during the next few years. The advantages of these methods need not be confined to large organisations. The establishment of computing centres, to which small workshops which possessed only one or two machines could send their planning sheets and receive in return magnetic control tapes, is a feasible and logical development.

Although the discussion and initial development has been confined to milling, as this was considered to be the most difficult problem, and the one most urgently requiring to be solved, the techniques are applicable to many forms of machining, assembly and production processes. The almost limitless scope and flexibility of the digital computer, which is frequently compared (rather loosely, it must be admitted) with the human brain, coupled to accurate servo-mechanisms which can carry out its commands at great speed, places a very powerful tool in the hands of the production engineer, and may have consequences in industry as far reaching as the invention of steam power.

Booklet on Cast Iron.—"Meehanite in the Service of Industry" is the title of a booklet which has recently been issued by the International Meehanite Metal Company, Ltd., Meerion House, 4, Downside, Epsom, Surrey. Applications of "Meehanite" described fall broadly into four groups, viz. general engineering and cases calling for special resistance to heat, wear and corrosion. Among the items mentioned by way of illustration are aircraft pump liners, carburetter plunger blocks and brake shoes, tank brake drums, complete sets of diesel engine castings, including crankshafts, and castings for machine tool components, where the stability of the material is of special importance. Castings of dies can be made closely to form, with only a small machining allowance, and the good strength and resistance of "Meehanite" grades to heat, abrasion and corrosion are shown by many illustrations taken from mining, electric power generation, furnace construction, and the chemical and metallurgical industries.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

COAL AND THE NATIONAL FUEL POLICY

SIR,—This letter anticipates the debate which is to take place, but it is felt that many things need saying, and had there been a vigorous fuel and power policy during the years since the war, the present impasse would never have occurred. That criticism of the affairs of the National Coal Board is justified, no one can deny, but the Government itself cannot escape blame, a fact which is borne out by the admission of the Minister of Fuel and Power in the House on July 11th, that "The National Coal Board's import policy is primarily determined by the Board and the Government have not dissented from that policy." However, it will not help British industry to weather the very difficult years immediately ahead, merely to attack the National Coal Board or the Government. This country must accept the fact that, for various reasons, coal production is down, while the demand is constantly increasing. The latest figures indicate that the quantity of deep-mined coal produced during the first half of 1955 was 2,500,000 tons less than in the corresponding period of 1954, whereas home consumption was 1,460,000 tons more than in the same period of 1954. The Chancellor of the Exchequer recently emphasised that production must continue to rise and costs be kept down, and that although this country's exports had been increasing, foreign competitors had been doing better still. It was absolutely vital that industry should achieve and maintain a competitive level of costs. The effect of the National Coal Board's statement is clearly reflected by the current depression on the stock market.

The immediate future is very critical indeed, and unless the fuel problem is tackled immediately and boldly, incalculable harm will be done to British industry. However, it is quite obvious that the recent increase in the price of coal not only can, but must be accepted as a challenge to the nation, and this challenge can be accepted with confidence. Following last week's announcement that the price of coal would be increased by 18 per cent, a spokesman of the National Industrial Fuel Efficiency Service stated that this company had found few factories in general industry in which fuel consumption could not be cut by 15 per cent to 20 per cent. The chairman, Sir Leslie Hollinghurst, stated in March this year that 5000 separate industrial establishments had been visited in less than one year from the formation of N.I.F.E.S., these visits having been made at the invitation of the managements. There is no doubt that a magnificent start has been made, but it seems to me that the organisation is, to some extent, at any rate, hamstrung because the element of compulsion is missing. It is agreed that power costs in many industries may only account for, say, 3 per cent or 4 per cent of the total production costs, but in certain specific industries, the ratio is often as high as one-third.

It must be conceded, too, that the increased use of oil fuel can make an important contribution towards bridging the gap which must exist before nuclear power stations revolutionise our present ideas of power and heating techniques. However, the output of the various products produced by a refinery must be balanced, i.e. fuel oil, petrol, and so on, and this problem is not an easy one to solve. The Central Electricity Authority publication entitled "Britain's Nuclear Power Station Programme," suggests that by 1975 about 25 per cent of the total generating capacity of the Authority will be met by nuclear stations. There is no doubt that coal must be imported in the immediate future, but it is not at all clear why the quantity so involved seems to be about double that needed for immediate requirements, unless it is required for stock-pile purposes. It is obvious that, under the present programme, the financial burden of the National Coal Board will have to be passed on to industry to bear, and the handling of such large quantities of foreign coal will increase the freight charges for all other commodities. This is not only applicable to Atlantic shipping, but it is common knowledge that the bulk* of American coal is transhipped at Continental ports before reaching Britain. The machinery of coal ports, designed for export, cannot easily be reversed. Is the position really as Gilbertian as it seems ? To the uninitiated, it might seem that in trying to export coal to the Continent we are actually subsidising our overseas neighbours. Why should they not buy for themselves direct from the United States ?

It is generally known that a Government loan scheme exists for the purpose of helping industrialists to install fuel-saving appliances, but it seems obvious that the upper limit which is now imposed will have to be raised considerably, and this would only involve a tithe of the cost of the coal import programme. The money should, therefore, be diverted to the encouragement of efficient coal utilisation, thus relieving the country of the need for importing coal from abroad. It is not at all clear why the Central Electricity Authority cannot import such coal as it needs for its own requirements, even if, in so doing, it loses money, rather than add to the financial burdens of the National Coal Board, which must bring repercussions on industry, as well as involving innocent private consumers who are still subject to rationing. Mr. Alfred Robens suggested in the House of Commons recently that some form of industrial rationing should be imposed, and that if fuel consumers did not set their house in order, their supplies would be reduced. This calls to mind Sir Oliver Lyle's suggestion, some years ago, that an excise duty of £7 per ton should be imposed on the then current coal prices to prevent industrial coal from being wasted needlessly.

The present impasse could well have been avoided had a vigorous power policy been enforced over the years since the war, and the present difficulties are due, as Mr. Gerald Nabarro, M.P., has rightly pointed out, to a total lapse of fuel and power policy and administrative incapacity. Mr. Nabarro's knowledge of these matters is considerable, and his enthusiasm is genuine and unbounded. His moral courage in resigning from the joint secretaryship of the Conservative Fuel and Power Committee is to be applauded, and only tends to emphasise the dire seriousness of the present position.

It is obvious to all engineers, and fuel technologists, throughout the country that we shall be faced with an extremely difficult problem during the next ten years, or more, and it cannot be too strongly emphasised that the subject of heat utilisation—whether for space heating, or for process requirements—is of equal importance to, say, correct stoking practice or high boiler efficiency. Important economies can undoubtedly be made in industry if attention is paid to the following :—

(1) The training of stokers.

(2) The extended use of mechanical stokers in the smaller industrial boiler plants.

These two will lead to increased efficiency, as well as to a reduction in atmospheric pollution.

(3) A greatly increased use of back-pressure generating plants which are capable of showing far higher thermal efficiencies than those obtainable with large public generating stations.

(4) The use of waste heat from diesel engine plants.

(5) The prevention of waste in factories, i.e. in steam-using appliances, by the provision of efficient insulation for machinery, pipework and buildings and by attention to such matters as the return of condensate to boiler hot-wells.

(6) All forms of waste heat recovery, such as from kilns, for drying or steam-raising.

It should be emphasised, here and now, that in numerous, but not all instances, considerable economies can be effected with a very low capital expenditure. In conclusion, there is a human side to this matter. Coal mining accounts for the loss of many human lives ; in fact, the average number of deaths per year caused in mine accidents since the war has been about 480 persons. In view of this fact, surely it is criminal not to make the best use of a fuel which is so hardly won.

JOHN FOX
M.I.Mech.E., F.Inst.F.

Hove, Sussex,
July 14th.

*According to Chamber of Shipping of the United Kingdom about 50 per cent. ED. THE E.

"GAS TURBINE SERIES," VOL. I

SIR,—Your anonymous reviewer of Mr. Hodge's book pays a graceful compliment in saying that a series written by members of my company's staff might be expected to be the most detailed account of the gas turbine yet published. It seems only proper, however, to point out that he is gravely in error in suggesting that all the volumes in the series in question are to be so written.

The second book in the series has already been published and is the work of Dr. D. B.

Spalding, of Imperial College. The remaining books will all be written by specialists in their respective fields and the Power Jets' Consultancy Department has been proud to accept responsibility for general editorship; the series should therefore be still at least as valuable as if all the volumes were in fact written by members of the Power Jets' staff.

So much for your reviewer's interpretation of what is written on the title page of Mr. Hodge's book. In view of my association with the author, it would perhaps be unseemly for me to comment on the criticism of the book itself.

T. G. HICKS,
Managing Director,
Power Jets (Research and Development) Ltd.
July 4th.

Literature

The End of the Line. By BRYAN MORGAN. London: Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, W.8. Price 25s.

IT was remarked not long since by a well-known and widely travelled contemporary critic that he really believed how "in most cases it is better to read about a place than to go there." Astonishing it certainly is that people who have actually visited regions famous for scenic beauty and historic interest will often know less about them than those who, from fireside chairs, have read authentic and well-wrought descriptions of such places. Readers in both categories will find sheer pleasure in journeying with Mr. Bryan Morgan to *The End of the Line*, and, like the present reviewer, will be sorry when they reach it. Described by the sub-title as "A Book About Railways and Places Mainly Continental," it appears to cater as much for the general reader as for the railway enthusiast and so long as the volume remains in print there will not be lacking a delightful appreciation of a large number of railways which, during their existence, were the means of affording a vast amount of pleasure. One often hears people declaring that they "have not been in a train for years." Dipping into this choice and richly illustrated encyclopædia relating to the smaller and lesser known railways in Holland, Belgium, France, Italy, Austria, Switzerland and Germany one realises how much such people must have missed. In a recent lecture, Dr. Igor Sikorsky referred to the "scenic" advantages possessed by the passenger-carrying helicopter; but, indeed, hardly any of the enjoyment reflected by *The End of the Line* could have been imparted to passengers in an aircraft of conventional type. For example, there is no better way of seeing large regions of Eastern France than from the rear-end vestibule windows (when available) of the "Rapides" which run between Paris (Est) and Bâle. If the passenger is not deterred by the notice "Réservé au service" he can sit on a flap-seat, watch France slipping past at a steady 110km per hour and be thrilled by memories of the historic places through which he passes. Who among us can forget the sight of the walled city of Langres seen from the "Rapide" as it traverses the Plateau de Langres? This is but one glimpse. Another follows when the train passes Notre Dame de Vesoul. It is also interesting and agreeable to descend at Troyes (where engines are changed) and have a word with the friendly and most expert drivers of the steam locomotives still used on these notable "Rapides." Rarely will the train be other than on the tick of time, and Mr. Morgan testifies, we note, to the outstanding punctuality which is a tradition on the S.N.C.F. There is no better way of testing this than to clock the arrivals, at Bâle, of the 7.45 "Rapide" from Paris, which, notwithstanding five intermediate stops, is allowed no more than 330 min for the 526km separating the Gare de l'Est from Bâle.

Mr. Morgan has an undisguised affection not only for the small locomotive, but particularly for the aged and the fantastic locomotive, whether "kneeling cows" or any other variety. He would agree with Sir Thomas Browne in that place where the philosopher, referring to whales, elephants, dromedaries and such like, remarks how "Ruder heads stand amazed at those prodigious pieces . . . but in these narrow engines (he refers to bees, ants, and spiders) there is more curious mathematicks." The author of *The End of the Line* turns, as it were, from the "Rheingold" (F10) with its immense Deutsche Bundesbahn 4–6–2 to the Moselbahn, with its "really distinctive locomotives." To Mr. Morgan the Moselbahn is "the supreme branch line of all Europe. . . . Perhaps it is too perfect: but in any case I want to say no more of it here, for whenever men who love Europe's railways meet it is accepted as a pattern and a paragon, as one of those things at the mention of whose name one keeps silence and remembers." Among the things for which the present reviewer looked immediately this delectable book came into his hands were any references to the rack railway up Monte Generoso, nor was he disappointed. Readers of *The End of the Line* should turn, after enjoying pages 165–166, to John Addington Symond's chapter on Monte Generoso (*Sketches and Studies in Italy and Greece*). Here they will find a superb account of what can be seen from the summit of this beloved mountain and they will be glad that while Symond had to foot it up Monte Generoso, there is now the rack railway referred to by Mr. Morgan. When last we passed Capolago the "Kneeling Cow" steam locomotive was semi-prostrate in the roadway as if gathering breath to make the ascent. It may seem slightly greedy in the face of such sheer abundance as is found in this book if we call attention to a short length of tramway which Mr. Morgan does not mention. This runs from Capolago to Riva San Vitali, and when last we saw it the track was disused, the route being served by a very occasional motor bus. Those who descend from the S.B.B. train at Capolago and wend their way to the ancient village of Riva San Vitali will be rewarded by the sight of a baptistery of the fifth century, the oldest Christian building remaining above ground in Switzerland. There is nothing more impressive of its kind between Bâle and Chiasso. The Tessin is rich in ancient monuments and Mr. Morgan would agree that travelling on the Gotthard line from Airolo to Bellinzona many passengers must long to drop off the train at quite a number of points, notably perhaps at Giornico, where close to the line stands the famous basilica of San Nicolao.

In his recent memoir on Hilaire Belloc, J. B. Morton relates how that singular genius "was an expert in little cross-country or mountain railways." In England he often astonished someone who was going on holiday in France by reeling off detailed information about the steam trams or the small railways in the part of the country the man was going to visit. Readers of *The End of the Line* will feel, as does the present reviewer, a powerful inclination to carry the book with them whenever they have the opportunity of spending any time on the Continent. It will, moreover, interest and entertain them even if they can but read it at home. To the railway enthusiast it is, of course, a sheer delight, but the humour, style and erudition of the author has created a volume which, apart altogether from its galaxy of pictures, provides a book of real interest to the general reader. A suggestion which may commend itself to the author is that so widely ranging a text would be the better for an index.

SHORT NOTICES

Aircraft Power Plants. By the Technical Development Staff of Northrop Aeronautical Institute. Revised edition. London: McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, E.C.4. Price 60s.—This volume is a companion to *Aircraft Basic Science* and *Aircraft Maintenance and Repair*. It assumes no previous knowledge of the subject and covers an extraordinarily wide field. Intended principally for the technician, its profuse illustrations frequently depict actual equipments, normally American, and routine adjustments and servicing of engines and many accessories are described. The chapter on injection carburettors includes a description of one type of direct injection system: this is one of several instances where fundamentals are not adequately set forth. With the near-eclipse of light aircraft in this country, the use of equal space to cover airscrews and turbine engines does not commend itself to the British reader, while the student will be disappointed to find no mention of sleeve valves, free-turbine engines or ducted fans.

Diesel Maintenance. By T. H. Parkinson. Edited by Donald H. Smith. Fourth Edition. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 12s. 6d.—This book, a companion volume to *The Modern Diesel*, covers the servicing and repair of the four-stroke oil engine with camshaft injection pumps, as used so widely in British automotive practice. Its approach is exclusively practical: it is regrettable that a more comprehensive index for rapid workshop reference has not been provided.

BOOKS RECEIVED

The Railway Engineers. By O. S. Nock. London: B. T. Batsford, Ltd., 4, Fitzhardinge Street, W.1. Price 18s.

An Introduction to Process Control System Design. By A. J. Young. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 42s.

Modern Surveying for Civil Engineers. Second Edition. By H. F. Birchal. London: Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 50s.

The Principles of Electromagnetism. Third Edition. By E. B. Moullin. London: Oxford University Press, Ltd., Amen House, Warwick Square, E.C.4. Price 45s.

British Chemicals and Their Manufacturers. London: Association of British Chemical Manufacturers (Inc.), Cecil Chambers, 86, Strand, W.C.2. Free of charge.

Engineering Inspection. Third Edition. By A. C. Parkinson. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 10s.

The T.V.A. An Approach to the Development of a Region. By G. R. Clapp. London: Cambridge University Press, Bentley House, 200, Euston Road, N.W.1. Price 27s. 6d.

British Petroleum Equipment, 1955/56 Edition. London: Council of British Manufacturers of Petroleum Equipment, 79, Buckingham Palace Road, S.W.1. Price 50s.

Progress in Cargo Handling. Papers read at the I.C.H.C.A. General Technical Conference, Naples, 1954. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 50s.

Applied Thermodynamics. Third edition. By E. B. Norris, E. Therkelsen and C. E. Trent. London: McGraw-Hill Book Company, Inc., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 53s. 6d.

Metallurgical Topics

Mechanical Twinning and Fracture

It is well known that the formation of Neumann bands in α-iron, now regarded as a type of mechanical twinning, is favoured by increasing the rate, or lowering the temperature, at which the metal is strained. D. Rosenthal and C. C. Woosley, Jr.,[1] studied the influence of the rate of application of stress on the position of the transition temperature from ductile to brittle fracture and also found, at each rate of strain, that there was a threshold temperature for twinning. They carried out tensile tests on a 0·19 per cent carbon steel at rates of deformation varying from 0·02ft to 275ft per second. The transition temperature to brittle fracture was −225 deg. Fah. for the slowest rate of deformation and was raised only 25 deg. Fah. for the 10,000-fold increase in the rate of strain. The threshold temperature of twinning increased from −170 deg. Fah. for the slow rate of strain

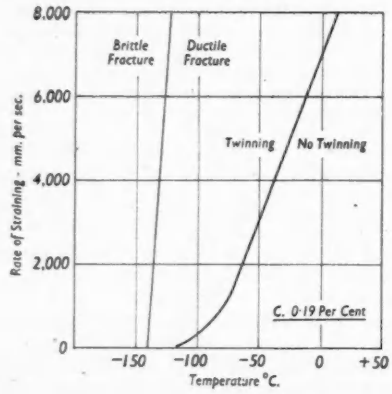


Fig. 1—Effect of temperature and rate of straining on the type of fracture and on the formation of twin crystals in 0·19 per cent carbon steel (Rosenthal and Woosley)

to +50 deg. Fah. for the fastest rate employed. For comparison with the recent work described below, on steels of lower carbon content, some of Rosenthal and Woosley's results are replotted in millimetre units and degrees Centigrade in Fig. 1, which shows that cleavage fracture was always accompanied by twinning, though ductile fracture, on the other hand, could occur with or without twinning. Hence, twin formation cannot be regarded as an immediate cause of cleavage fracture.

The influence of rate and temperature of straining on the type of fracture, and the conditions under which mechanical twinning occurred, have recently been studied by H. Buchholtz, F. Braumann and A. Eier.[2] They investigated four steels in different conditions of treatment by means of tensile tests carried out at rates of strain of 50mm to 4600mm per second and at temperatures between +80 deg. and −195 deg. Cent. The tensile tests were carried out in a

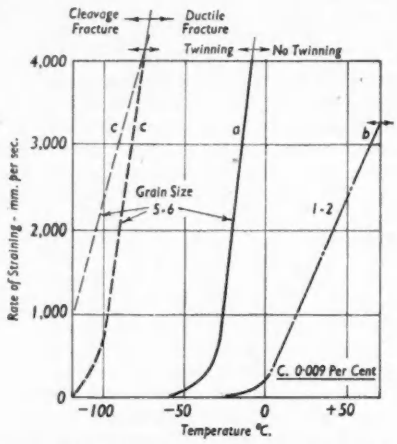


Fig. 3—Effect of temperature and rate of straining on the type of fracture and on the formation of twin crystals in 0·009 per cent carbon basic Bessemer steel (Buchholtz, *et al.*)

pendulum machine on smooth polished specimens, 5mm in diameter, gauge length 25mm, total length 55mm with ends threaded. The materials used were Armco iron, 0·009 per cent carbon basic Bessemer steel and 0·11 per cent carbon open-hearth steel, in three conditions: (*a*) normalised, (*b*) reheated to 850 deg. Cent. and cooled in air after 10 per cent cold work (large grain size), (*c*) reheated to 200 deg. Cent. and cooled in air after 10 per cent cold work (aged). The fourth material was a low-carbon chromium-vanadium steel in a severely embrittled condition.

In strain-rate/temperature diagrams, each of the first three steels exhibited three types of behaviour: in a low-temperature region, cleavage fracture with twinning, at higher temperatures ductile fracture with twinning or ductile fracture without twinning. From this it could be deduced that twin formation does not necessarily lead to cleavage fracture.

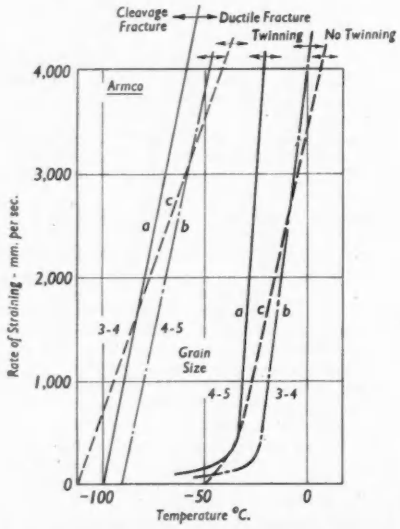


Fig. 2—Effect of temperature and rate of straining on the type of fracture and on the formation of twin crystals in Armco iron (Buchholtz, *et al.*)

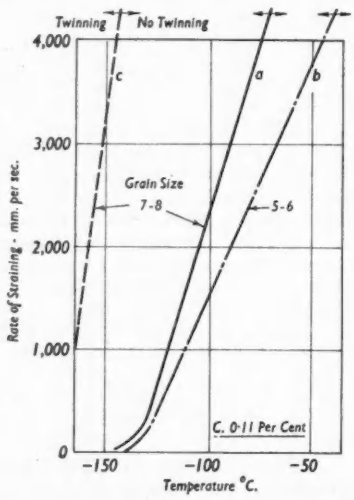


Fig. 4—Effect of temperature and rate of straining on the formation of twin crystals in 0·11 per cent carbon open-hearth steel (Buchholtz, *et al.*)

The position of the boundaries of the separate regions varied from steel to steel. It also depended on grain size. Fig. 2 shows the effect of rate and temperature of straining on Armco iron (carbon 0·04 per cent) in the three conditions mentioned above. Fig. 3 shows similar curves for the 0·009 per cent carbon basic Bessemer steel. In this case the cleavage fracture curves for the normalised and large-grained specimens lie below −195 deg. Cent. and only that for the strain-aged steel is shown. The position of the boundary line between regions of twin formation and absence of twinning was virtually unchanged for the normalised condition, but was displaced to a higher temperature for condition (*b*) owing to the larger grain size, and to a lower temperature for the aged steel. All three boundary curves for the 0·11 per cent carbon open-hearth steel (Fig. 4), which was of finer grain size, were displaced to lower temperatures than those shown by Armco iron. The chromium-vanadium steel was only tested in a severely embrittled condition, after being exposed as a tube to a temperature of 500 deg. Cent. for 15,000 hours at a pressure of 110 atmospheres (its notched-bar impact transition temperature was +80 deg. Cent.), and it showed either ductile fracture without twinning or brittle fracture with twinning, so the fracture transition curve and the border line for absence of twinning coincided (Fig. 5), giving the impression that the change in type of fracture was dependent on the formation of twins.

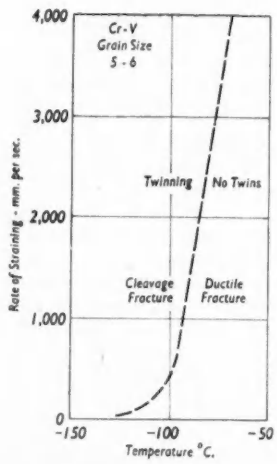


Fig. 5—Effect of temperature and rate of straining on the type of fracture and on the formation of twin crystals in steel containing carbon 0·11, chromium 1·39, vanadium 0·32 per cent (Buchholtz, *et al.*)

For each of the other materials, cleavage fracture could occur either with or without twinning. Reasons for this are discussed. In the higher range of temperatures, slip is possible in α-iron on three sets of planes (110), (112) and (123), and the formation of twins to accommodate applied stress is unnecessary. At lower temperatures and high rates of strain, slip is already more difficult and is confined to the (112) plane, to which twin formation is parallel, so that conditions are favourable to the formation

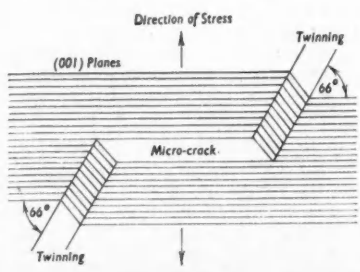


Fig. 6—Diagrammatic indication of the formation of micro-cracks and twin crystals

of twins. Twinning, however, does not accommodate all the stress, and is supplemented either by slip or, failing this, by the formation of microcracks along the (001) plane leading to cleavage fracture, as indicated diagrammatically in Fig. 6.

It is indicated in the paper that, by cleavage fracture, transcrystalline fracture is to be understood, as distinct from intergranular fracture, of which the cause may be grain-boundary contamination—for example, by oxygen.[3]

The formation of transcrystalline micro-cracks in α-iron is illustrated in the paper, but no micrograph is given of the fracture of the chromium-vanadium steel. In view of the somewhat anomalous behaviour of the chromium-vanadium steel in comparison with the three carbon steels, the question may be raised whether the fractures in this case were transcrystalline cleavage fractures or intercrystalline fractures which are commonly found in temper-brittle steels.

REFERENCES

[1] *Welding Journal*, 1952, Vol. 31, page 475 *s*.
[2] *Archiv Eisenhüttenwesen*, June, 1955, page 337.
[3] W. P. Rees and B. E. Hopkins : *Journal Iron and Steel Inst.*, 1952, Vol. 172, page 403.

Factors Affecting Ductility of Chromium

BOTH the physical condition and the purity of chromium are important factors in determining the degree of ductility of the metal at temperatures near atmospheric. In order to identify some chemical factors which may affect the ductility, workers at the Battelle Memorial Institute have prepared chromium of the highest possible purity by the iodide process and have determined the effect of the deliberate addition of various impurity elements on its properties.[1]

By fabrication in a temperature range just below the recrystallisation temperature, chromium sheet having an average ductile-to-brittle bend transition temperature well below room temperature can be obtained. When arc-melted iodide chromium was used, the lowest bend transition temperature, −25 deg. Cent., was found for metal which contained 0·006 per cent oxygen, less than 0·002 per cent nitrogen, and a total of about 0·02 per cent of metallic elements.

It was found that increasing amounts of nickel (up to 0·1 per cent) or of molybdenum (up to 0·5 per cent) generally increased the bend transition temperature. In this respect, the effect of individual metallic contaminants, present in small amounts in unalloyed iodide chromium, could be taken as equivalent and additive. With nickel above 0·2 per cent the chromium could not be worked. Oxygen (0·006 to 0·37 per cent) or nitrogen (0·001 to 0·032 per cent) had no significant effect on bend ductility. On the other hand, carbon and sulphur were very detrimental. When carbon was over 0·015 or sulphur was over 0·02 per cent, the metal could not be rolled, and smaller amounts destroyed bend ductility at room temperature.

Bends round axes parallel to the rolling direction showed the transition at 200 deg. Cent. higher than samples bent round axes perpendicular to the rolling direction. Recrystallisation tended to neutralise this effect, but invariably resulted in an increase in the average bend transition temperature over that obtained from samples cut longitudinally from the wrought sheet.

When all possible precautions had been taken about composition, the metal still remained extremely sensitive to surface conditions. Minute surface irregularities or scratches either parallel or perpendicular to the rolling direction increased the transition temperature by about 50 deg. Cent. Several wrought sheet tensile specimens, with bend transition temperatures well below atmospheric, showed brittle fractures at 28 tons per square inch or less. This brittle behaviour was due to surface imperfections unavoidably introduced in preparing the test specimens. The beneficial effect of removing surface layers was pointed out two years ago by Wain and Henderson, and later confirmed by Johansen and Asai.[2] In more recent work, the Australian investigators, H. L. Wain, F. Henderson and S. T. M. Johnstone,[3] have again confirmed that loss of ductility due to surface condition could be overcome by etching. They found that, after electro-polishing, chromium could give an elongation of up to 15 per cent in room temperature tests. Roughening of the surface caused a fall in elongation to 11 per cent and finally to 0. Recrystallised material was more sensitive to embrittlement by surface defects or by impurities than wrought material.

In general, there was agreement between the American and Australian workers, but the upper limit of nitrogen found to have no significant effect on iodide chromium was greater than that given by Wain, Henderson and Johnstone, who found that 0·02 per cent of nitrogen rendered chromium brittle in the bend test. This embrittlement by nitrogen could be caused by heating the specimen in air for two hours at 650 deg. Cent.

The large-scale production of ductile chromium is still a remote possibility, but conditions tending to minimise its brittleness are getting to be better understood.

REFERENCES

[1] D. J. Maykuth, W. D. Klupp, R. I. Jaffee and H. B. Goodwin : *Journal Electrochem. Soc.*, June, 1955, page 316.
[2] See THE ENGINEER, April 1st, 1955, page 453.
[3] *Journal Inst. Metals*, December, 1954, Vol. 83, page 133.

Effect of Rare Earth Metals on Steel

As a result of an investigation carried out at the Armour Research Foundation,* the claim is made that the addition of rare earth elements (in the form of 2½ lb of *mischmetall* per ton) to a nickel-chromium-molybdenum steel leads to an improvement in its transverse impact properties. The steels employed were of the following composition :

	Per cent		Per cent
Carbon	0·27	Nickel ...	1·57
Silicon	0·12	Chromium ...	1·18
Manganese ...	0·76	Molybdenum	0·18
Phosphorus ...	0·015		

with 0·020 or 0·038 per cent of Sulphur.

These and the same steels with an addition of *mischmetall* were put through an identical programme of treatment and tests. The steel with the higher sulphur had a lower energy

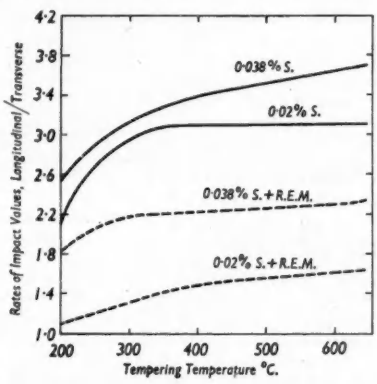


Fig. 1—Effect of sulphur content and of rare earth metal additions on the ratio of longitudinal to transverse impact value

absorption in notched-bar impact tests, irrespective of rare earth additions, but the addition of the rare earth metals caused a substantial increase in transverse impact value at all hardness levels. Longitudinal impact tests were unaffected, but owing to the improvement in transverse tests the ratio of longitudinal to transverse impact figure was greatly reduced (Fig. 1). For example :

	Impact value, ft-lb	
	Tempered 200 deg. Cent.	Tempered 650 deg. Cent.*
Longitudinal tests (with or without rare earth metal additions)		
0·020 per cent Sulphur ...	25	90
0·038 per cent Sulphur ...	20	60
Transverse tests (without rare earth metal additions)		
0·020 per cent Sulphur ...	12	30
0·038 per cent Sulphur ...	8	16
Transverse tests (with rare earth metal additions)		
0·020 per cent Sulphur ...	22	55
0·038 per cent Sulphur ...	12	27

Neither sulphur nor the rare earth elements had any effect on the transition temperature of tough to brittle fracture, nor on the hardness.

* H. Schwartzbart and J. P. Sheehan : *Iron Age*, May 26, 1955, page 103.

This adds another reputed advantage to those already claimed for the use of rare earth metal additions to steel (increased fluidity, counteraction of hot-shortness, improved machinability). The cost of rare earth metal additions is high, and though it may be that for some purposes such additions may prove to be worth while, there are other methods in current metallurgical practice whereby a high standard of transverse properties of a steel can be ensured.

Comparison of Schnadt and Charpy Impact Test Pieces

THE impact resistance of mild steels (carbon 0·06 to 0·16 per cent ; tensile strength 22 to 32 tons per square inch) as a function of the temperature has been determined with the Schnadt test pieces K_0, K_1 and K_2 and with the Charpy keyhole test piece. The results of this co-operative investigation have been reported by C. Schaub.* The Schnadt test piece has a 5mm

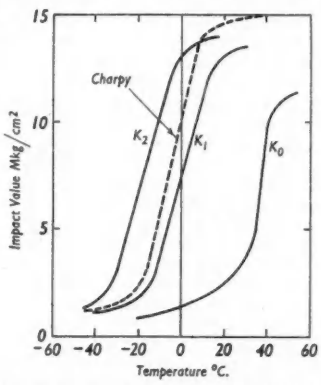


Fig. 1—Results of Charpy and Schnadt tests on a normalised 0·09 per cent basic open-hearth steel (Schaub)

diameter hard steel pin inserted in the side of the specimen opposite the notch to withstand the first stages of deformation in compression. The notch of each type of Schnadt specimen was 2mm deep, leaving a depth of 3mm below the notch to be broken through. The specimen K_1 had a V-notch with a root radius of 0·5mm ; K_2 a V-notch with a root radius of 1mm. The notch K_0 consists of a V-notch with a root radius of 0·5mm, 1·5mm deep, extended a further 0·5mm by a very sharp incision having a root radius of 0·05mm. The Charpy keyhole notch is 1mm radius, 5mm deep, with 5mm depth below the notch.

The comparison was based on a determination of the position of the lower boundary of the transition range, defined as the highest temperature at which no single impact value exceeded 2 mkg per square centimeter. With the test pieces K_1, K_2 and Charpy, practically the same lower transition boundaries were generally found, while K_0 gave considerably higher temperatures. The last mentioned test piece was thus more severe than the others. An example is shown in Fig. 1. The order of merit for the steels investigated, arranged according to increasing lower transition boundary, was generally the same with all types of test piece. Photo-elastic stress analysis showed that the stress distribution in the early stages of bending was practically the same in the solid test piece as in the test piece with a steel pin, provided that the fit of the pin was very accurate.

The investigation showed that the Schnadt test pieces had certain disadvantages, but as regards results they are on the whole equivalent to other test pieces.

* *Jernkontorets Annaler*, 1955, No. 5, page 326.

CEMENT PRODUCTION IN 1954.—The Blue Circle Group of Cement Companies has published a booklet reviewing the group's achievements in 1954. During that year deliveries of nearly 9,200,000 tons of cement were made, and the man-hours needed to produce 1 ton of cement were reduced to 1·87 (the figure for 1946 was 2·75).

Combined Pulverised Coal and Oil Fuel Firing for Power Stations

An auxiliary oil firing unit has been designed and developed by Fuel Firing, Ltd., to improve the efficiency of pulverised-fuel-fired boilers. The initiator, which has been designed to meet an exacting specification and incorporate numerous safeguards, burns heavy oil fuel, is push-button controlled, and includes many electronic devices which cause the initiator to come into operation or retract according to combustion conditions.

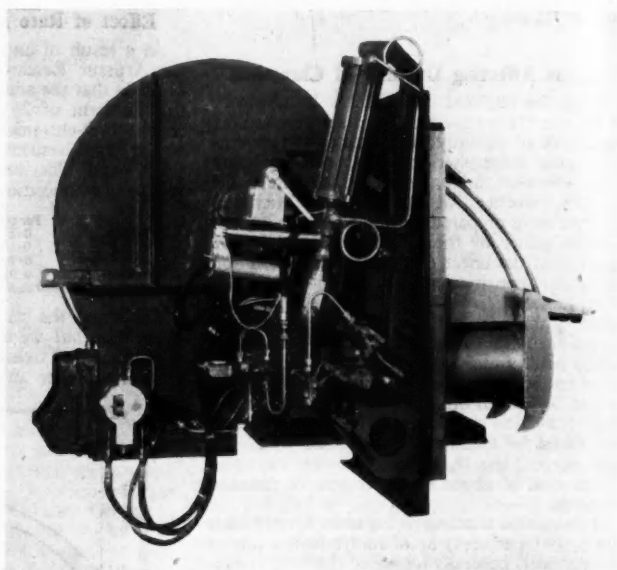
SINCE its formation in 1951, Fuel Firing, Ltd., of Woodley, Reading, Bucks, has been engaged in the design and development of an auxiliary oil firing unit for use with pulverised-fuel-fired boilers and for the express purpose of improving the efficiency of such boilers. To do this the unit was required to give rapid and positive ignition to pulverised fuel and raise boiler pressure without overheating the superheater elements and also be able to stabilise combustion against the risk of flame failure and explosion due to interruption of coal supplies. The fulfilment of the basic requirements presented a number of technical difficulties to the designers, including the question of economics, since to achieve low running costs it was essential for the burner to operate efficiently with heavy fuel oil in a fully cooled furnace. Another requirement was that the unit, since it operates intermittently, must be capable of being brought rapidly into action and be retractable with arrangements for the automatic sealing of the furnace port. The operational speed and the size of the unit called for the design of remote and fully automatic control incorporating various safeguards. Reliability in operation combined with a minimum of maintenance was of primary importance and required the unit to withstand temperatures and conditions of differential expansion associated with the hottest part of the furnace. In the intervening years progress has been made steadily to satisfy design requirements, and teething troubles have been overcome one by one as each successive prototype eradicated faults observed in a previous model.

In the development process a total of eight prototypes has been constructed, each incorporating modifications suggested by experience, such as the replacement of high-tension ignition by a 10V resistance igniter ; a mechanical cut-off for the oil supply ; closing plates redesigned to give complete sealing of the furnace port ; improved pneumatic drive ; and improved electronic control of the fan. The testing of prototypes and their development under actual operating conditions has been carried out at the Earley power station of the Southern Division of the Central Electricity Authority, where a pulverised fuel-fired boiler was made available for this purpose. Recently we were able to visit the Earley power station to examine the latest burner units operating under service conditions. Two burner units, known as initiators, and operated from the boiler control panel, were put into the furnace and ignited and then, after an interval, were withdrawn. Later the initiators were put in again and the ignition of the pulverised fuel was demonstrated. In another test the supply of pulverised fuel was reduced to a level sufficient to cause flame instability and possible failure to illustrate the safeguards provided by electronic viewers which at a predetermined furnace temperature level caused the initiators to swing into position, ignite and maintain furnace temperature until the coal supply was restored. The whole of the various tests was under observation and televised so that flame conditions were continuously visible on the screen and a point of interest was that the pulverised fuel was ignited by radiant heat from the furnace wall and not directly from the oil burner.

Description of Initiator

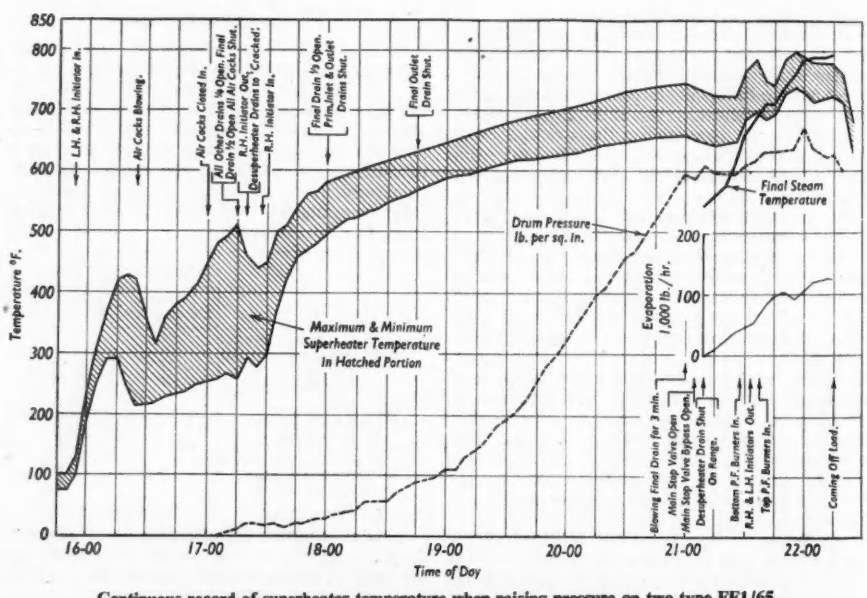
Our illustration gives a general view of a Mark F.F.1./80 initiator, which consists of a fan, igniter, oil atomiser, air duct, controls, sealing plates, air and oil connections, and a pneumatic operating arm all assembled as a unit. It is mounted on trunnions which enable it to rotate through 90 deg. This movement allows the burner to be retracted from the furnace so that it is not subjected to possible damage by radiant heat. When withdrawn, the main sealing plate, which is deeply finned to give rapid natural cooling, partly closes the burner opening, the remainder being covered by a gravity overlapping top plate.

One of the difficulties inherent with the use of heavy grade fuel was the need to avoid unburnt oil which causes contamination by falling into the ashpit, depositing carbon in the furnace, causing carbon black to be carried through the plant and possibly causing fires, and also may produce excessive smoke. This problem was overcome by the adoption of the gas turbine pattern Lucas atomiser in association with correct air supply and control. In the atomiser the oil, which may have an initial viscosity of up to 960 seconds Redwood No. 1, and is raised to a temperature of about 220 deg. Fah., passes through a multi-hole plate, a plate with four holes and, finally, a plate with a single central orifice, into the furnace to form a cone roughly measuring 12ft in length and 6ft diameter, containing a homogeneous distribution of finely atomised oil. The atomiser, which can be withdrawn by hand, is carried in a sprayer tube which is arranged to provide primary, secondary and tertiary air, supplied at about 5in water gauge by a two-stage fan mounted integrally with the initiator and driven by a surface cooled induction motor. Air from the fan is discharged into the sprayer tube, which has its axis intersecting that of the trunnions, and is divided to give three separate air supplies at the burner head. The primary air establishes the stability of the flame and keeps the atomiser cool and free from carbon and the secondary air is introduced, around the primary air, through a set of vanes which surround the burner and are set at a critical angle to correspond with the angle of the cone of oil mist, and to give a swirling movement to the air. Finally, the tertiary air enters through an annulus surrounding the secondary air vanes to complete combustion. Besides ensuring complete combustion of the oil the air supply ensures that the unit is self-cooling even when the main coal burners are operating.



Side view of a Mark FF1/80 initiator in the firing position, showing the igniter extended, the oil valve operating mechanism and the pneumatic control cylinder

Above the main air tube is a housing, fitted with a hinged flap at the furnace end and cooled by air bled from the fan ducting, which contains the igniter element, consisting of a carbon rod in contact with a copper disc. When required,



Continuous record of superheater temperature when raising pressure on two type FF1/65 initiators only on a 200,000 lb/hr p.f. fired boiler

the igniter is projected forward into the atomiser spray by means of a pneumatic cylinder and held there for the time sufficient to cause ignition and then withdrawn behind the protective door. For safety there are two oil valves in series which are operated by a quadrant on the main tilting shaft and which remain closed up to 60 deg. of angular movement and thereafter gradually open. On withdrawal the mechanical operation of the valves ensures positive cut-off so that there is no purging of the sprayer. Air for the pneumatic cylinders is taken from the 80 lb per square inch station instrument panel air supply line and about 1½ cubic feet of air is used for each operation.

Operation and Control

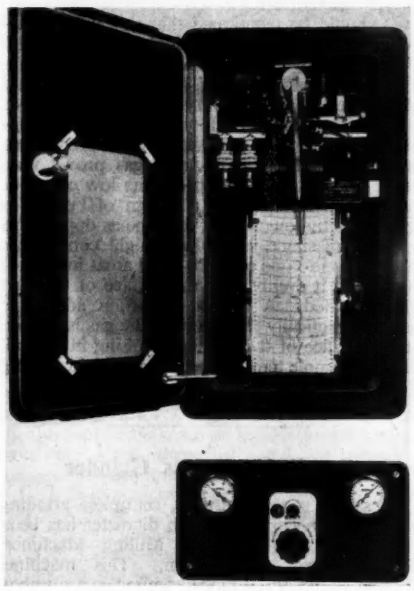
Operation of the initiator is from a control station consisting of two push buttons, six indicator lights and a four-position rotary selector switch. The "start" button, when pressed, energises a solenoid valve which causes compressed air to be admitted to a pneumatic cylinder which swings the initiator into the furnace. This movement operates an auxiliary switch which energises another solenoid valve, through a time delay relay, and this directs compressed air to a second cylinder which controls the position of the igniter. The correlation of movement is such that when the burner tube has swung through 60 deg. and is at 30 deg. from the horizontal, the igniter is projected from its housing and becomes white hot immediately it is extended. Simultaneously with the swinging of the burner towards the operating position a quadrant mechanically starts to open two series connected high pressure oil cocks which admit oil to the atomiser when in its operating position, and ignition takes place. The normal time from pressing the "start" button to establishing the flame is about two seconds.

At this stage the control panel indicator lights show "Fan On," "Igniter In," "Flame In," and the time delay relay, already noted as being in action, continues for a further period of three seconds before causing the withdrawal of the igniter into its housing, when the "Igniter Out" indicator light is shown on the control panel. Should ignition not take place then the time delay relay, acting in conjunction with an electronic flame failure device mounted on the closing plate, causes the initiator to swing out of the furnace and the "Flame Out" indicator to appear on the control panel. After withdrawal due to flame failure the initiator cannot be operated again until the "Shut Down" button has been pressed to reset the flame failure relay. An amplified impulse signal from the photocell when indicating "Flame In" starts up the fan and then air pressure in the ducting causes a switch to indicate "Fan On." The "Flame Out" indicator automatically reverses the procedure and shuts the fan down. Other safeguards are incorporated in the unit and the initiator is automatically shut down and withdrawn when there is a failure of the electrical or compressed air supplies, a failure to ignite from the igniter or loss of ignition during operation. In addition there is the combustion stability control, which consists of two electronic viewers. The "Monitor" viewer is set to close a relay at a certain furnace temperature and so causes an initiator to come into operation to maintain the flame. Any failure in the circuit also operates the initiator. Secondly, there is the "Lockout" viewer, which is set to close when a furnace has become extinguished and to cut off electric supply from the initiators.

The successful operation of the equipment with high viscosity oil in fully-cooled furnaces made the raising of pressure on a boiler from a bank or cold position and the safeguarding of superheater elements from overheating feasible. Tests, raising pressure from cold using two initiators, were carried out on a boiler at the Earley power station and temperatures of the superheater elements were checked by means of thermocouples, placed across the width of the boiler, and a multi-point continuous recorder. Our graph shows one set of results from which it can be seen that the metal temperatures did not rise to a dangerous level. With pressure raised with the initiators, hot air is available for the pulverising mills and so the starting of the coal-firing plant is simplified and initial combustion improved. Although the tests showed the possibilities of raising pressure from the cold position by means of the initiators the economic aspect had to be considered and costs using the initiators only were compared with those for the combined coal and oil system. It is understood that the engineers of the Central Electricity Authority found that using the initiators reduced the fuel bill and gave evidence of its resulting in reduced maintenance charges.

Wobbe Index Controller

We illustrate below an instrument introduced by George Kent, Ltd., and the Sigma Instrument Company, Ltd., which is designed to control supplies of town's gas in factories to a desired Wobbe number by either automatically adding a small amount of air to the incoming gas, or trimming the output of a mechanical mixing machine by an additional supply of gas. The Wobbe index is a function of calorific value and specific gravity and the new controller, a combination of the Sigma Wobbe index recorder and the Kent Mark 20 air-operated controller, enables corrections to be made for changes in both calorific value and specific gravity.



The Sigma-Kent Wobbe index controller

The controller provides a means of overcoming problems which have arisen, for example, in the electric lamp and radio valve industries, resulting from small changes in gas characteristics, specially specific gravity. With the instrument highly critical industrial processes, such as those connected with automatic glass-working machinery, can now be controlled more accurately and with higher rates of working, because it enables a constant heat transfer to be obtained at the gas burners and makes frequent adjustment of flame length unnecessary.

The new control instrument represents an extension of the arrangement between the two companies, which already jointly produce a controlling calorimeter. The Wobbe recorder is designed specially for control purposes and has a very high rate of response. It consists of three main components: a flow regulator, a heat exchanger, and a flow recorder. The function of the flow regulator is to supply gas to a burner in the heat exchanger at a constant pressure. The amount of heat developed by a gas burner in any given time depends on the four following factors: the size of the orifice controlling the discharge of gas; the differential pressure across the orifice, i.e. gas pressure; the calorific value of the gas; and the specific gravity of the gas.

If the size of the orifice in the line to the burner is constant and the regulator maintains a constant differential pressure across the orifice, the heat released from the burner is directly proportional to the calorific value and inversely proportional to the square root of the specific gravity. Heat input to the work, therefore, varies as the Wobbe index.

The heat exchanger consists of two concentric vertical steel tubes through which the products of combustion pass to atmosphere. The lower ends of both tubes are rigidly joined together, the upper end of the outer tube being fixed to the instrument case. A bar attached to the upper end of the inner tube transmits the relative expansion or contraction of the inner tube to the recording linkage. This relative movement is directly consequent on changes in the Wobbe index of the gas being burned. Ambient-temperature changes have no effect on the apparatus because, in this instance, both tubes respond equally and no motion occurs at the upper end of the inner tube. The relative movement of the inner tube is magnified many times by the recording linkage, giving adequate motion to the pen on the chart.

The Kent pneumatic controller is mounted within the instrument case and is arranged to detect very small deviations of the recording pen from the desired value setting pointer through a differential linkage system. The pointer can be set instantly at any Wobbe value desired. The controller mechanism translates the deviation into a change in air pressure in the automatic-control system, which embodies proportional, integral and first-derivative functions of the deviation. This pressure is used to reposition a regulating valve controlling the addition of air or of gas in the mixing system, thus restoring the Wobbe index of the gas supply to the desired value in the shortest possible time.

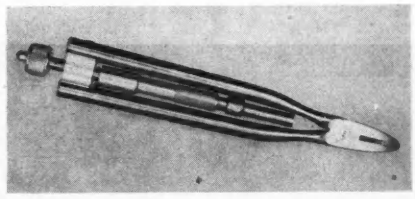
Experiments with an exothermic furnace-atmosphere generator have shown that great precision of furnace-atmosphere composition can be obtained by controlling the gas mixture to the combustion chamber at a fixed Wobbe index value.

Inquiries concerning the "Sigma-Kent" Wobbe index controller should be referred to George Kent, Ltd., at Luton.

Wire Twisting Tool

A wire twisting tool which is quick and simple to operate when applying locking wires which have to be twisted tightly after looping through components, is being made in this country by Douglas Kane Associates, 55, Pall Mall, London, S.W.1. This tool is of American design and is illustrated below.

It consists of a pair of special pliers with a twisting assembly mounted on the inside of one of the handles. When the two wires to be



Tool for twisting locking wires on components

twisted together have been gripped between the jaws a knurled sleeve on the central spindle is slid back for the rear end of the sleeve to register over a locking projection on the inside of the other handle. With the wires thus firmly gripped between the jaws a knurled knob projecting beyond the ends of the handles is pulled. The spindle of this knob has a spiral cut along its length and passing through a mating spiral bore in the tool. As the spindle is pulled out the remainder of the tool is spun round on the spiral of the spindle and so twists the wires.

At the end of the twisting operation the jaws are released by sliding back the knurled sleeve, the spindle is pushed back ready for the next operation, and the wire can then be cut to length by side cutters in the jaws.

Flame Hardening of Crankshafts

IN the description of the Peddinghaus system and equipment for flame hardening with the use of town's gas and oxygen, which appeared in THE ENGINEER of February 29, 1952, it was mentioned that plant of this kind had been developed for the surface hardening of crankshafts. One of these automatic crankshaft surface hardening plants using oxygen and town's gas has been installed at the works of Ruston and Hornsby, Ltd., Lincoln, and was recently demonstrated in operation to the Press. This new installation can be seen in operation in the two illustrations below.

The heating unit of the installation comprises individual sets of water-cooled copper burners for each crankpin and journal. The burner incorporates three heads with slots to cover the width of the zone to be hardened. In the case of a two-cylinder crankshaft five sets are used, two for the pins and three for the journals; for a six-cylinder crankshaft thirteen sets are used, six for the pins and seven for the journals. The quenching unit is provided with an equal number of spray quenches. The crankshaft to be hardened, which is manufactured in En. 12 steel, is held between centres on a movable carrier having three positions, which are controlled by the operator.

The hardening operation is commenced by loading the shaft in the neutral position midway between the burner and quench units. By moving the shaft into the heating position the gas and oxygen valves supplying the burners are automatically opened and the burners ignited from a small pilot jet. This movement also starts the motor used to rotate the crankshaft at approximately 45 r.p.m. The machine is equipped with two master crankshafts of the type to be hardened and to them are coupled the arms of the burners and quenching nozzles so that they follow in correct relation the movement of the pins as they rotate. By this arrangement the two pins and three journals of the two-cylinder crankshaft are hardened in one operation, whilst crankshafts for more than two cylinders have the bearings hardened in groups.

When the shaft is in the heating position the "Milliscope" automatic temperature control system of the plant comes into operation and serves to indicate to the operator the correct moment to move the heated shaft over into the quenching position. "Milliscope" heads, to be seen at the rear of the machine in our illustration, provide a check on the job as it is heated and work in conjunction with two dials on an indicator panel. On this panel the temperature at which the component should be hardened is manually set on the left-hand dial and the needle of the right-hand dial starts moving towards the zero point 25 deg. before the preset temperature (in this instance 810 deg. Cent.) is attained, thus giving a visual warning to the operator that the moment of quenching is approaching. When the needle reaches the zero point the operating lever is pulled to bring the shaft into the quenching jets, and this movement automatically opens the water valve. At the same instant a variable time switch is set in operation and this subsequently closes the water valve, allowing some heat to remain in the material to give a predetermined back tempering effect and complete drying. The motor for rotating is then automatically switched off as the shaft is brought into the neutral position for removal.

In this installation the heating operation takes 100 seconds and the quenching a further 45 seconds, thus the entire operation for the two-cylinder shaft takes just over two minutes. If required, the depth of hardening may be controlled by adjusting the burners to vary the length of time taken for the bearings to attain the preset temperature.

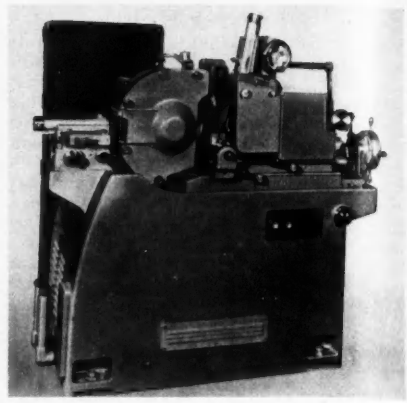
It should be mentioned that this use of oxy-town gas for flame hardening was initially developed by Peddinghaus, of Gevelsberg, Germany, during the war, and the plant is being distributed in this country by Surfard Ltd., of Abbey House, S.W.1. It is claimed by Peddinghaus that a mixture of 60 cubic feet of oxygen to every 100 cubic feet of town gas provides an ideal fuel, not only because of its low cost, but also because it permits a design of burner to give a continuous ribbon of flame as opposed to a series of single jets, which might concentrate the heat on to one or more small areas instead of spreading it evenly over the surface of the part being heated. A further important advantage is that practically the whole of the gas is burned at the orifice of the burner, resulting in a small flame of ample temperature for the rapid heating of the surface to be treated.

Small Centreless Grinder

A SMALL general-purpose, centreless grinding machine for work up to ½in diameter has been introduced by Cincinnati Milling Machines, Ltd., Tyburn, Birmingham. This machine, known as the No. 0 model, embodies a number of the principal points in design of the larger centreless grinders made by the firm. It is designed for use with grinding wheels from 12in to 16in diameter and regulating or control wheels from 7in to 9in diameter, each with a maximum width of 4in. It is illustrated herewith.

The highly finished alloy steel grinding wheel spindle is mounted in one of the maker's "Filmatic" multiple segment bearings, which are self adjusting for variations in loading. Plain thrust bearings are fitted and any stoppage of the automatic lubrication system feeding the bearings cuts out the driving motor. The grinding wheel is driven through three vee belts by a 5 h.p. motor mounted in the base of the machine.

The regulating wheel assembly is mounted on two wide dovetail slides on the base to provide



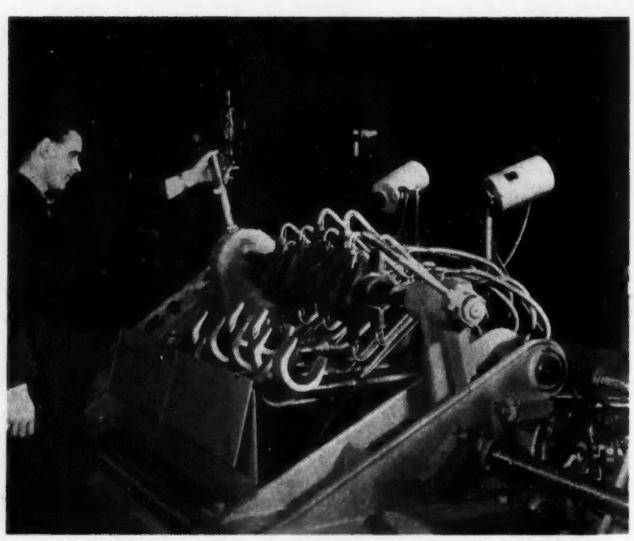
General-purpose, centreless grinder for work up to ½in diameter

adjustment of the work rest in relation to the wheel, and of both the work rest and regulating wheel with respect to the grinding wheel. A swivel plate fitted between the lower slide and the base permits correction of slight errors in straightness without retruing the wheels. The regulating wheel is driven by a ½ h.p. motor through wide vee belts and variable-pitch pulleys which are controlled through a handwheel to give a stepless range of speeds from 22 r.p.m. to 300 r.p.m. Final drive to the wheel spindle is transmitted through a worm and worm wheel, and a tachometer is fitted to facilitate spindle speed setting.

The regulating wheel slide assembly is adjusted by a large handwheel with reference to a micrometer dial, and a convenient hand infeed lever is fitted for use when plunge grinding.

A hydraulically operated grinding wheel diamond truing attachment trues the wheel to a straight cylindrical shape or to slight tapers if required. A hydraulically operated profile diamond truing attachment is also available for the machine.

Oxy-town-gas automatic flame hardening machine for crankshafts, with shaft in loading position



With the crankshafts in the burner unit, the surface temperature of the pins and journals is raised to 810 deg. Cent. in about 100 seconds

Kitimat-Kemano Power Transmission Line Carrier System

A POWER transmission line carrier communication system for the Kitimat-Kemano scheme (British Columbia) of the Aluminum Company of Canada has been supplied and installed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. The normal line voltage between Kitimat and Kemano is 300kV, and this is the first power line carrier system to be superimposed on such a high-voltage line in North America. It will be recalled from an article in our issue of May 29, 1953, page 777, that the generating station at Kemano is separated from the aluminium smelting plant at Kitimat, which it supplies, by 50 miles of mountainous country which is impassable by road. Further, at the time of installation there was no telephone connection between the two sites, the only means of communication being by a v.h.f. radio link which necessitated maintaining a repeater station in extremely difficult terrain. The power line carrier equipment is designed to operate on an inter-feeder basis : the signals are transmitted between one phase of one feeder and the corresponding phase of the other feeder. The wave traps (Fig. 1) are rated for 1600A steady line current. The system, in addition to providing the usual speech and signalling facilities, also provides unidirectional transfer tripping facilities, so that if a fault occurs anywhere in the overhead lines the feeder breaker at Kemano is tripped.

The two sites are linked by three duplex telephone channels, one of which provides a direct connection between the two control desks for

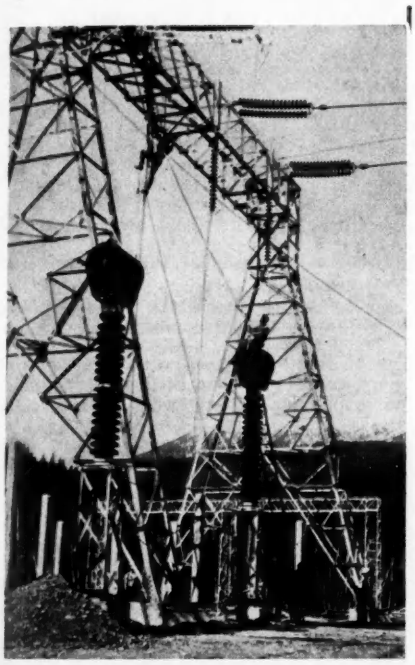


Fig. 1—Carrier coupling equipment being installed on the transmission line at Kitimat. The two wavetraps can be seen in the foreground

the control engineers. The remaining two channels work between the telephone exchanges at the two stations and provide for fully automatic communication between the subscribers there. A telemetering channel also operates from Kitimat back to Kemano to indicate the line voltage received at Kitimat. All common equipment is duplicated and, in the event of a fault occurring, the changeover from normal to standby equipment is automatic.

The power line carrier equipment is the G.E.C. type "N" multi-circuit equipment (Fig. 2), which is readily extensible to an ultimate capacity of five circuits. It is also provided with additional automatic gain control facilities to maintain the level of the circuits at their nominal value even during the unusually severe weather conditions experienced.

The a.c. supply for the type "N" equipment

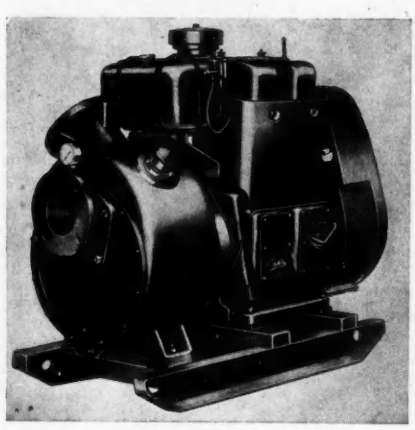
Fig. 2—Rack-mounted carrier equipment installed in the telephone exchange at Kitimat next to the control room

is obtained from a four-machine generator set, the function of which is to maintain an uninterrupted power supply to the power line carrier equipment in the event of a failure in the main supply. Under normal conditions the local a.c. power supply drives a three-phase induction motor coupled to a single-phase alternator by means of a flywheel. A supply failure would cause a standby d.c. motor to be energised from the station storage battery, and to drive a single-phase alternator. During such a changeover the flywheel on the main set maintains the output from the main alternator until the standby machine has run up to speed.

Each communication channel is 4 kc/s wide and consists of a speech channel from 300 c/s to 2700 c/s and a telephone signalling channel of 3060 c/s, leaving space for the accommodation of six super audio signalling channels in the remaining part of the frequency band.

Centrifugal Self-Priming Pump

WE illustrate herewith a centrifugal self-priming 4in pump now being made by Arthur Lyon and Co. (Engineers), Ltd., Telford Way, London, W.3, which is designed to deliver up to 30,000 gallons per hour. The pump is spigot mounted directly to the crankcase of a Petter air cooled engine developing 10 h.p. at 1500 r.p.m. Its impeller is fitted on a shaft bolted to an extension of the engine crankshaft.



Skid-mounted 4in centrifugal self-priming pump

The three bladed open impeller is capable of handling solids up to $\frac{3}{4}$in across and has a wearing plate fitted in front which can readily be removed and replaced. When it is required to replace either the seal, the impeller or the front wearing plate it is not necessary to remove the main body of the pump, and wear can be taken up by the addition of shims behind the impeller boss on the shaft.

Pump priming is effected by water recirculation and quick and effective priming is obtained by the use of adequate recirculation passages, ample priming water and a large chamber for the separation of air and water. No priming valves or moving parts are contained in the priming system. The water after leaving the volute is directed to the bottom of the body of the pump before ejection from the discharge, so that solid matter does not collect in the body of the pump, so keeping the priming passages clear at all times. A simple non-return valve of hard wearing rubber fitted to the inlet ensures quick repriming under all circumstances, even when the pump is working on "snore." A drain plug is fitted to the bottom of the body of the pump and as this drains the whole of the pump, including the volute, complete protection is given against frost and cold weather.

In its standard form the pump can handle water up to 100 deg. Cent., and water containing abrasive materials and certain mineral oils up to 80 deg. Cent. With special fittings it can be arranged to handle other liquids as well as dilute acids, alkaline solutions, &c.

A Tractable Marine Boiler

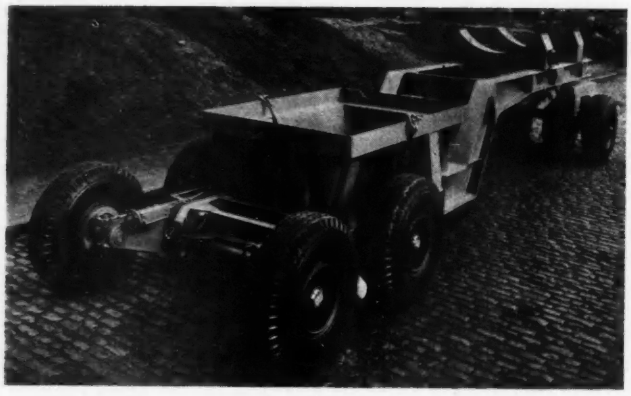
MERCHANT marine service demands control of steam temperature in order to allow efficient running below full power and to permit manœuvring at short notice. A boiler recently developed by Babcock and Wilcox, Ltd., offers this facility with lower running costs than those of the twin-furnace boiler.

Gas leaving the furnace is divided into two flows by a stud-tube wall, one flow heating saturated tubes only and the other both the superheater and convection tubes. The distribution of gas between the two is controlled by a damper in the form of butterfly valves, and since there is little change in the pressure drop across a butterfly valve in the range "full open" to "half open," the boiler is designed to give full design power with both valves half open and the two are coupled together. In its simplest form this damper consists of two long butterfly valves mounted on a single shaft running across the flue. The material of which the dampers are made is selected to give freedom from distortion, and since their operating temperature is relatively low, corrosion and fouling do not occur.

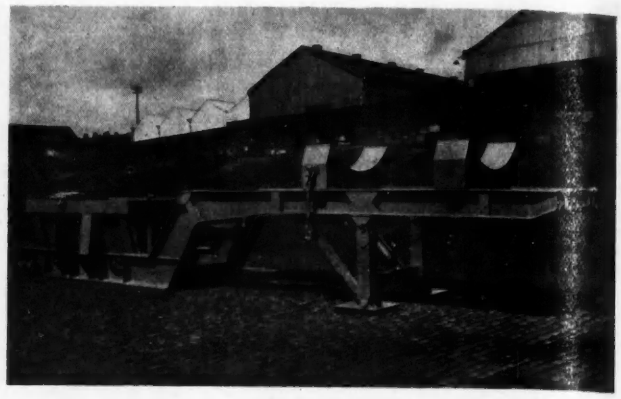
Thus, simply by adjusting this one control the steam temperature can be altered over a wide range ; the makers claim that this boiler lends itself well to automatic control. The superheater tubes are of W form and access to them for inspection and washing is claimed to be easy. Otherwise, the normal features of an integral furnace boiler are retained, the design incorporating cyclones so that the water in the steam drum is essentially bubble-free.

An additional advantage of this design is that saturated steam in great quantities for cargo pumping and other purposes can be provided without the need for a large desuperheater. It is claimed that the boiler, a model of which will be displayed at the Engineering, Marine and Welding Exhibition, has been proved under conditions more arduous than those of normal sea-going service, and that a number of installations are already in hand.

BULLETIN OF MECHANICAL ENGINEERING EDUCATION.—Issue No. 8 (July, 1955) of the *Bulletin of Mechanical Engineering Education*, published by Manchester Municipal College of Technology, contains a number of papers on the teaching of engineering drawing and design, including the use of stereoscopic pictures, and apparatus used in the study of engineering mechanics. Professor H. Wright Baker describes a device for the testing of dial gauges, which is a development of an instrument recently invented at the N.P.L. Other papers deal with problems of thermodynamics, beam experiments and engineering graphics.



Boiler-transporting trailer, with frame in position on bogies



Transporter frame as used on a site working position, with bogies removed and frame supported on firebox base and front support assembly

Boiler Transporting Trailer

We illustrate herewith one of a number of trailers built by R. A. Dyson and Co., Ltd., Liverpool, for the Assam Oil Company, Ltd., for use in the transport of large locomotive-type oilfield drilling boilers between sites. The trailer frame is designed to provide a permanent mounting for the boiler on site and the pneumatic-tyred bogies are used for handling a number of frame units in turn. The trailer chassis incorporates a built-in firebox and boiler cradles, and the boiler itself is secured to the trailer frame by turnbuckles and chains. At an operating site the front and rear bogies are removed and the boiler is "fired" in position on the frame.

An essential part of the design of these trailers is the arrangement whereby the bogies can be quickly and easily removed. The front carriage is released by operation of a lever which frees jaws used for locking the king pin during transit. The carriage can then be removed, leaving the front end of the frame supported on a retractable support assembly. The rear bogie is carried on a single cross shaft and by undoing clamp bolts it can be released from the frame.

The centre of gravity of the frame and boiler assembly is so positioned that when the support strut at the front is retracted the boiler tips forward on the cranked bottom of the frame in front of the firebox, raising the back end so that the rear bogie can be rolled away. The front end is then raised by the support assembly until the unit is horizontal with its base resting on the ground, as shown in our second illustration, ready for operation.

The boilers each weigh approximately 28 tons and the saving in time and transport cost using the trailers is claimed to be appreciable. The built-in fire-boxes of the frames will be lined with refractory bricks at site, when the boilers are mounted. The burners for firing the boilers will then also be fitted and use will be made of the oil-field's natural gas as fuel for the burners.

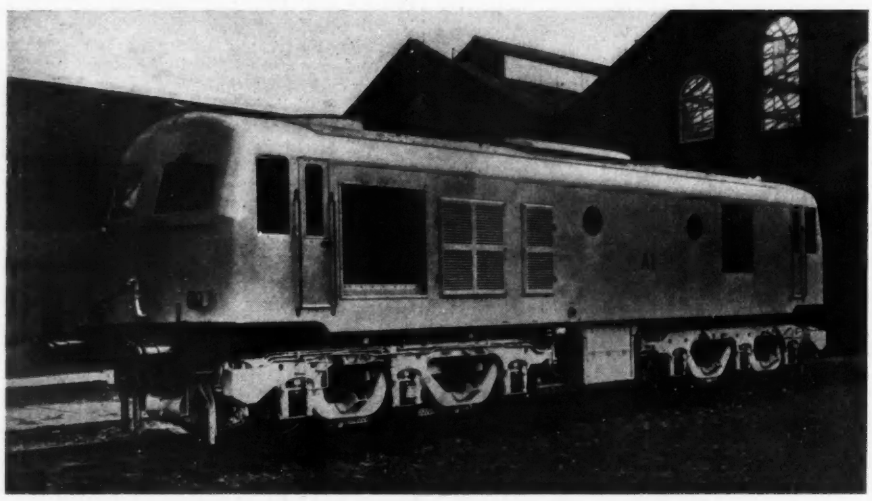
Each trailer is 41ft long and is fabricated from mild steel sections and electrically welded throughout. The detachable rear bogie has a central cross shaft on which two balance beams oscillate. Each of these balance beams is fitted with two stub axles, on which the wheels are mounted. The detachable, swivelling, front carriage has two short oscillating axles in line, each axle assembly being mounted on a heavy duty trunnion-ended spring.

Diesel-Electric Locomotives for Eire

The first of the ninety-four diesel-electric locomotives ordered a little over a year ago by Coras Iompair Eireann has been delivered by the Metropolitan-Vickers Electrical Company, Ltd., and the firm is now completing the order at a rate of eight locomotives a month. The order, valued at some £4,750,000, covers sixty 1200 h.p. C_0-C_0 and thirty-four 550 h.p. B_0-B_0 locomotives for 5ft 3in gauge. Work is now proceeding on both types, but only the larger are approaching completion as they are required to be delivered first.

One of the new C_0-C_0 locomotives is illustrated below. It has a steel body with a completely enclosed driver's cab at each end and is mounted on a rigid fabricated steel underframe. Each of the axles of the two cast steel, three-axle, bogies is driven through single reduction gearing by a 330A, 620V traction motor. Power is supplied by a vee eight-cylinder, two-stroke, Crossley diesel engine rated at 1200 h.p. at 625 r.p.m. This engine has three-point suspension and is directly coupled to a 750V, 3300A generator with a continuous rating of 1208A, 620V. An auxiliary generator on the end of the main generator supplies power for auxiliaries at 110V d.c. The locomotive is designed for a maximum tractive effort of 55,000 lb and a continuous effort of 1700 lb, its maximum speed being 75 m.p.h. with full power available up to 60 m.p.h. In full working order it weighs 85 tons.

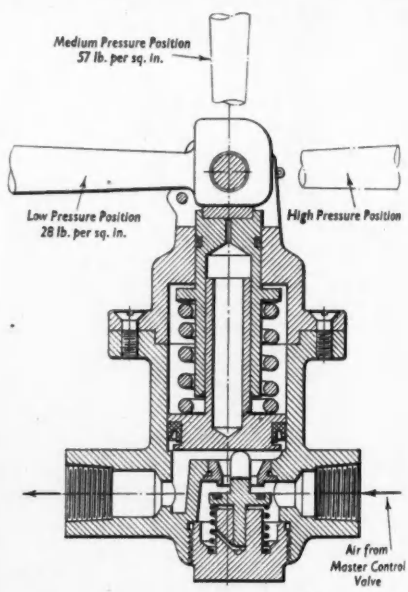
The driver's controls are duplicated on each side of the cab and the instruments and gauges are grouped on a panel. Automatic engine output control mechanism ensures that the engine power is maintained at a constant value at any notch position of the master controller.



1200 h.p. diesel-electric locomotive for Coras Iompair Eireann

Valve to Limit Braking Effort

An adjustable braking control for vehicles on which the weight distribution changes very markedly, such as tractors and truck-trailer combinations, has been introduced by Clayton Dewandre Company, Ltd., Titanic Works, Lincoln, under the title of the "light laden valve." The new valve is intended for air pressure braking systems, and by a setting of a lever can restrict



Cross section of adjustable braking valve for air-brake vehicles

the pressure applied to those brakes governed by the valve to either of two predetermined values, corresponding to the light vehicle case and the partly laden case. In the third position of the handle the valve does not affect brake operation. As can be seen in the illustration, the unit functions simply as a reducing valve, and the distribution of braking effort is unaffected until the valve closes; thereafter the remaining brakes of the vehicle only can be applied harder. Besides reducing the risk of loss of control of the trailer, use of this valve can improve tyre life.

High-Speed Mobile Cranes

A SERIES of demonstrations were given recently by Ransomes and Rapier, Ltd., Ipswich, of a new mobile crane for high-speed operation now being made by the firm in two models with capacities of 6 tons and 7½ tons. These cranes are generally of similar design and one of the 6-ton models is illustrated on this page.

The crane has a rigid steel frame chassis surmounted by an "A" frame structure at the apex of which the lattice-braced cantilever jib is pivoted. It is carried on pneumatic-tyred wheels, four being mounted in twin formation on the front driving axle and two on the rear steering castor. The design is such that the crane always remains steady on its wheels and its stability is maintained under all working conditions without the use of props or jacks. If it is grossly overloaded the tail of the crane tends to rise instead of the load being lifted, and this gives the driver ample time to correct his mistake before the crane becomes unstable.

6-ton diesel-electric mobile crane designed for high-speed operation

The crane is powered by a Perkins "P.6" diesel engine developing 70 h.p. at the maximum governed speed of 2000 r.p.m. and its fittings include a vacuum pump used to operate the axle gear shift and a "Hydrovac" vacuum-assisted braking system. Drive is transmitted through a Borg and Beck 14in dry plate clutch and a gearbox giving three forward and three reverse speeds. Final drive to the front axle from the gearbox is through a triple roller chain reduction drive, and the pinion of this drive is mounted on an eccentric for chain adjustment purposes. The driving axle is fitted with an "Eaton" two-speed unit, the change mechanism of which is operated by a push-pull button on the main gear change lever. This button operates a vacuum gear shift diaphragm mounted in the axle assembly. With the main gearbox and the two-speed axle drive the crane has forward travelling speeds from 3·4 to 10 m.p.h. and reverse speeds from 3 to 8·7 m.p.h. When loaded it can climb inclines of 1 in 5 and when unloaded 1 in 8.

The axle of the steering castor is pivoted in a king post at the tail of the crane so that its wheels can accommodate themselves to uneven ground and ensure that the crane is always supported on three points—the two front wheels and the castor post.

The hoisting and derricking motions are each driven by a 10 h.p., 1200 r.p.m. motor, to which current is supplied by a compound wound dynamo driven by the main engine and developing 70V at 800 r.p.m. and 250V at 1800 r.p.m. at 37½A. These two motion motors each drive grooved winding barrels through worm boxes and spur reductions; each motor being fitted with a self-adjusting magnetic brake which sustains the load or jib when the circuit is broken. The brakes are designed to adjust themselves to the wear of the brake linings and need no attention other than lubrication. Powerful regenerative braking can be effected by switching off the engine with the appropriate control in the "on" position. In this way the heaviest load can be lowered at creeping speed. Overwinding switches limit hoist and both directions of derrick.

On the model "6" crane the hoisting speeds vary from 6 tons at 23ft per minute to 3 tons at 30ft per minute; whilst on the model "7" crane a 7½-ton load can be raised at 20ft per minute and 3¾ tons at 28ft per minute. On each model the full range of derricking is completed in sixteen seconds. The maximum load can be lifted at 4ft 6in outreach on each model of the crane, whilst the No. 6 can lift 3 tons at the maximum outreach of 11ft 4in and the No. 7 can lift 3¾ tons at 11ft 4in. If required, jib extensions can be supplied to give higher lifts and larger working radii. A load indicator fitted on the "A" frame in full view of the driver shows the loads that may be lifted at any position of the jib. In the enclosed driver's cab simple reversing switches control the hoisting and derricking motions and normal automobile controls are used when travelling.

Burning Colliery Slurry

SUCCESSFUL experiments have been completed by the National Coal Board with a new type of automatic mechanical stoker to burn the slurry which is composed of the fine particles of coal and soluble shale rejected from washeries. This use of slurry is common practice on the Continent, and German and Dutch engineers have proved that with it they can generate power more cheaply than it can be bought from the grid. It was after a study of these methods that the Coal Board decided to install what is the first plant of its kind to operate in the country.

The new equipment is of German design and is known as the "Martin" stoker. It has been adapted and installed at Llay Main Colliery in North Wales, where it has been consuming about 650 tons of slurry a week. This fuel has replaced the 450 tons of washed small coal previously used at the colliery to raise steam on water-tube boilers fired by chain-grate stokers and hand-fired Lancashire boilers. Savings of £1000 a week have been achieved as a result of changing the fuel and the experiment at Llay Main indicates that raw slurry can be burned satisfactorily on a modern water-tube boiler.

At Llay Main installation the raw slurry is taken from the pond by mechanical grab, loaded into wagons and transported to a vertical-sided 60-ton bunker. At the base of the bunker are screw feeders with disintegrators mounted at the delivery end to break up the fuel before it passes down a wide feed chute. The fuel is sprayed on to the fire bed of the combustion chamber of the boiler by air jets. An inclined fire grate incorporates reciprocating fire bars which agitate the fuel as it travels to the lower end of the chamber to be discarded as ash. As slurry has a high moisture content, which makes it difficult to spread, a constant movement is necessary in the combustion chamber so that the fuel bed is continuously broken up. The system used ensures that hot fuel is continuously mixed with incoming coal and wet material, and even in the winter, when ice and snow were mixed in with the slurry, there were no difficulties with ignition.

It has also been found that the "Martin" stoker can deal with a fluctuating load, which is important in the operation of colliery boilers; the fuel bed can be banked down for as long as two or three days and steam can then be raised quickly, merely by starting up the fans and feeding fuel to the grate.

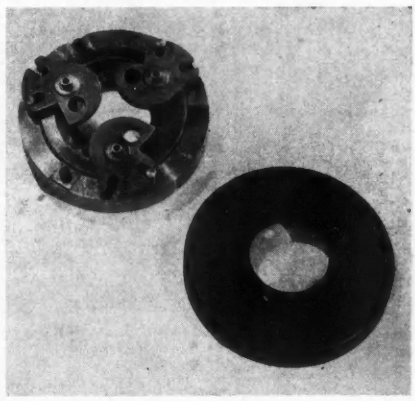
The new plant went into operation on January 9th and has been in routine operation ever since. By June 1st it had steamed for about 3000 hours, burnt about 14,000 tons of slurry and carried about 40 per cent of the regular colliery steam load. The installation cost £130,000 and includes a 50,000 lb an hour water-tube boiler and accessories, the stoker, coal and ash-handling plant, feed water treatment plant and other equipment.

We are informed that further installations are being considered, and one is already under construction at Bowhill Colliery in Scotland.

Self-Gripping Work Driver

QUICK loading and unloading of parts turned between centres is made possible by the work driver shown in our first illustration. The equipment is manufactured by F. Pratt and Co., Ltd., Lister Lane, Halifax, Yorkshire, in a range of sizes covering all classes of centre lathe work from $\frac{5}{16}$in to 5¼in diameter. The construction of the device may be seen by referring to our second illustration. The ring shaped jaw carrier floats inside an outer ring which has three pins which engage with the slots in the jaws, the ring itself being fastened to the lathe spindle. By rotating the cover plate which is fixed to the jaw carrier, the serrated jaws which are spring-loaded are made to grip the workpiece, or release it according to the run of rotation. The arrangement is such that the cutting torque will tighten the jaws further, while the floating assembly permits oval work to be held securely. By setting the jaws over so that they engage the pins with their other slot, the range of each set of jaws is increased.

Quick-gripping, quick-release work driver for centre lathe work. It is operated by hand without any tools being required



Work driver partially dismantled. The outer ring with the driving pins is mounted on the lathe spindle. To increase the range of each set of jaws, the pins are made to engage the second slot

Six-Spindle Bar and Chucking Automatics

Two six-spindle automatics were recently added to the production equipment made by Wickman, Ltd., of Coventry, one being a 2in capacity bar machine and the other a 6⅜in capacity chucking machine. The two machines are basically similar in design and differ only in their mechanisms for bar or chucking operation. The bar machine is illustrated below.

This machine is driven through vee belts by a 25 h.p. 1450 r.p.m. motor, and its gearbox, which provides a comprehensive range of feeds and speeds, has large multi-disc clutches and brakes. All controls are duplicated at the front and rear and a lever provided for manual engagement of the fast motion clutch cannot be accidentally engaged. In the large attachment drive compartment of the machine all the drives are designed to permit quick and easy introduction as complete units.

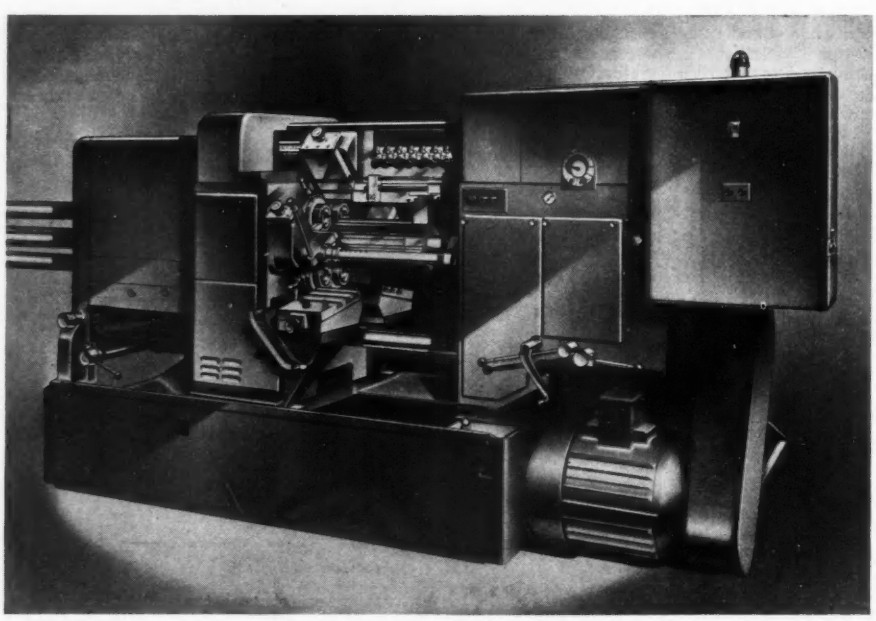
Twenty-four spindle speeds from 111 to 1302 r.p.m. are available and the spindles, which are driven from a large centre shaft, are mounted on taper and parallel roller bearings. The collets are closed by toggles fitted with a preloaded compensating device which provides for variation in bar size whilst maintaining the gripping power and giving ample opening movement to allow free feeding of the bar. Bar feeding is by means of cam controlled springs and the length of feed is adjustable from ½in to 10in. An auto-stop device can be used to stop the feed at a point where the collet is open and stock in any spindle is depleted.

When the spindle drum is indexed accuracy is ensured by over-running it past its latch and then drawing it back by a toggle mechanism. The guide of the main block indexes with the drum. On the standard machine the independent slides on the main block have a feed stroke of up to 5in with an idle stroke of 3¾in, the block itself having an idle stroke of 3½in. In special cases these idle stroke lengths can be increased by ½in.

Means of micrometer adjustment are provided for the six cross slides, and for special tooling either the intermediate or the upper cross slide on each side of the machine can be timed independently. All of the slides have an independently variable feed stroke which is from zero up to 1¾in on the lower, 2in on the upper and 1¼in on the intermediate slides. Attachments for diehead screwing or tapping can be fitted in four stations, and for high speed drilling in all stations.

The six-spindle chucking machine is designed to swing work up to 6 11/16in over the main tool block and 5in over the tool block faces. It is driven by a 20 h.p., 960 r.p.m. motor and the spindle speed range is in thirty-two steps from 51 to 862 r.p.m. The spindles have large integral flanges for chuck mounting purposes and are carried in taper and parallel roller bearings. Each spindle is fitted with a large multi-plate clutch and brake operated by an individual fork. Flanged adaptors are mounted on the rear ends of the spindles and chucking air cylinders are attached by studs.

Each of the chucking cylinders is fitted with a combined running joint and valve to which the air hose is connected. A pressure safety switch is provided to trip the feed mechanism and prevent starting of the motor if air pressure for chucking purposes falls below a preset minimum safety level.



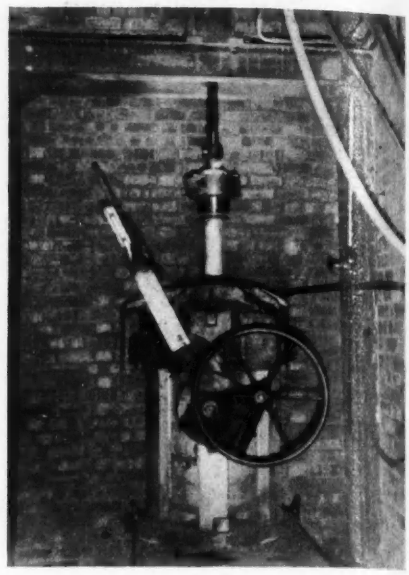
Six-spindle, 2in bar automatic

Two Modern Foundries

RECENTLY Lloyds (Burton), Ltd., held a series of "open days" to mark the tenth anniversary of the opening of the firm's Wellington works at Burton-on-Trent, and the formal opening of a new foundry at the Derby works of Parker Foundry (1929), Ltd. When Lloyds (Burton), Ltd., acquired the Wellington works after the late war it was first used as a mechanised foundry for the production of carbon steel castings and high-duty irons. Of more recent years the production of castings in ductile iron, manganese steel and low alloy carbon steels has steadily increased. As part of the "open day" celebrations an interesting exhibition was arranged to show a wide selection of the different types and sizes of castings made in the works, as well as representative engineering equipment in which the castings are used.

During their tour of the various sections of the foundry on the "open days" visitors were able to see the very high degree of mechanisation which has been introduced and inspect some of latest equipment installed, including a large shell moulding plant. The capacity of the originally installed cupola furnaces for iron and convertors for steel has been greatly increased by the recent introduction of two 3½-ton arc furnaces for steel and a 3½-ton receiver for iron, which is used as a holding furnace. Recently the melting capacity for special iron or steel was further increased by the installation of a Russ "Elektroofen" 10,000 lb low-frequency induction furnace, which employs a two-core system and has a heating chamber of oval cross section.

For the manufacture of ductile iron under Mond Nickel licences, the firm has installed S.K.-B. "Druckpfanne" pressure ladle equipment for the introduction of metallic magnesium into molten iron. For this process a charge of



Pressure ladle in protective chamber with overhead gear in position for introducing magnesium charge

molten iron is drawn off into a special pressure ladle which is then transferred on a rail bogie into the protective chamber shown in the accompanying illustration. A pneumatic cylinder mounted on a beam at the top of the chamber has a refractory extension depending from its piston, and on this extension there is fastened a sheet metal canister containing the magnesium charge. With the ladle centralised in the chamber the piston is extended to plunge the canister into the molten metal, and at the same time a flange above the refractory section seals the mouth of the ladle. In this way the explosive effect of the magnesium coming into contact with the molten metal when the canister disintegrates is confined within the sealed ladle and danger to operatives is eliminated.

In addition to demonstrating this equipment to the visitors a further demonstration showed the manufacture of high-duty cast iron by the duplex process, using cupola melting and low-frequency induction reheating. Other departments visited included a large fettling section, where a continuous pendulum conveyor "Wheelabrator" was shown in operation, the pattern shops and the machine shops.

Since it was acquired by F. H. Lloyd and Co., Ltd., a few years ago, the Derby works of Parker Foundry (1929), Ltd., has been completely rebuilt and re-equipped with modern plant. Some 25,000 square feet have been added to the productive floor area by the construction of a new melting shop, new bays and other extensions, and the capacity is now about 150 tons of finished steel castings a week.

The new melting shop at present contains an arc furnace capable of producing up to 5 tons of steel every two and a half hours, and provision is made for the installation of a second furnace. A new foundry bay for castings up to 8 tons in weight is some 325ft long by 60ft wide, and is served by 15-ton overhead cranes. A recent addition to the equipment of this bay is a Beardsley and Piper mobile "Speedslinger," which runs on a rail track 240ft long, and is designed to ram moulds situated at any point on the floor within 20ft of the track. This machine is designed to deliver sand at a rate of 45 tons an hour into the moulds. Four permanent casting pits in the shop, each about 20ft long by 14ft wide and 5ft 4in deep, accommodate castings up to 8 tons—the largest made in the foundry.

In the extended and re-equipped heat-treatment section two bogie, gas-fired, annealing furnaces have been installed, one 9ft by 18ft 6in by 7ft high and the other 6ft 9in by 16ft 6in by 7ft high. New shotblasting equipment in the fettling section includes a dual table 7ft 6in diameter "Wheelabrator" and a 10ft diameter table "Centriblast" with three abrasive throwing wheels.

Powered Steering on 7-ton Trucks

In view of the widely-held belief that once power-assisted steering comes into use in this country, it will rapidly establish itself and come to be regarded as essential, great interest attaches to the introduction by the British Motor Corporation of a range of diesel vehicles for 7-ton payloads.

The steering on this vehicle is power assisted on the constant flow system, a hydraulic pump for this purpose being driven by the engine. The control valve is of the reactive type, pre-loaded so that the servo action commences only when the driver's effort reaches 5 or 6 lb. There is a valve to limit the maximum supply pressure, so that above 14 or 15 lb. the additional effort must again be entirely supplied by the driver. The hydraulic motor takes the form of a double-acting ram mounted on the front axle and acting on the offside steering arm: since the control valve is on the drag link, four flexible hoses are needed. The steering wheel is of 20in diameter and the ratio of the steering box 20 : 1, so that only the force, and not the movement, required from the driver is reduced. Since, in the constant-flow system, there is no accumulator, this forms a safeguard against the consequences of missing a gear or the failure of the pump. "Feel" is present throughout the range of effort applied, so that slippery road surfaces or vehicle faults such as punctures are not masked, and the incentive to use the camber and ease bends is not lost. It appears that this installation would be adaptable to other vehicles, even if not originally designed to incorporate it.

The fluid used in the steering system is engine oil of S.A.E. 10W viscosity, all seals being synthetic rubber. The pump output is controlled at 2 gallons per minute and the maximum pressure is limited to 600 to 650 lb per square inch.

The basic layout of the vehicle is conventional, a six-cylinder engine driving a four-speed gearbox supplemented by a two-speed back axle. The hydraulic brakes are also power assisted, but in this case the energy is supplied by an engine-driven exhauster. The forward control cab has large rear windows and opening quarter lights in front of the doors. The gross weight is 10¼ tons and 20 gallons of fuel are carried. The vehicles are marketed by both Austin and Morris Commercial organisations.

100W D.C./A.C. Vibrator

A heavy-duty 100W vibrator, which was originally designed for Services use, is now available in commercial form from the maker, The Plessey Company, Ltd., Ilford, Essex. It can be used in a power pack to produce a.c. outputs, at various voltages, from d.c. inputs for supplying bias circuits, e.h.t. supplies and similar requirements, in situations where motor generators may be undesirable.

The vibrator is of a synchronous equipment, working at a frequency of 110 c/s (nominal), having a split reed and a separate drive, taking a maximum of 5W driving power. The platinum-iridium tipped drive contact screw is connected to a platinum-iridium contact spun on to the drive contact spring, made from high-quality spring steel. The power contacts are manufactured from close-grain swaged tungsten. Twin reeds are used and, to ensure uniformity of material, the reeds are manufactured in one piece connected together by a small web which is removed after the vibratory system is assembled.

Ground ceramic spacers are used throughout to ensure high mechanical-electrical stability during the life of the vibrator. All the materials used in the construction of the vibrator are chosen so that no injurious gases are produced over the working temperature range (−40 deg. Cent. to +70 deg. Cent.).

The vibrator equipment is hermetically sealed in an aluminium case, 4¼in high and 2¼in diameter, the wall thickness being such as to keep transmitted noise to a low level. Typical performance figures for a power pack are: input, 24V, 8A d.c.; output (d.c.), 350V, 140mA, or (a.c.), 12V, 500mA to 6·3V, 350mA. The power pack efficiency is specified as 60 per cent, including rectification, smoothing and r.f. filtering, and the weight is given as 12·6 ounces.

Indian Electrical Industry

BY OUR INDIAN CORRESPONDENT

Almost 30 per cent of the total expenditure on the Five-Year Plan now running in its last year has been allotted to irrigation and power, and of this, Rs. 291 crores* had been spent by the end of the financial year 1953–54, leaving a margin of Rs. 333 crores to be spent by the close of 1955–56. The latest report of the Planning Commission, published in April, 1955, and covering the period up to September, 1954, states that "on the whole, satisfactory progress has been maintained in respect of various irrigation and power projects included in the Plan," and refers to an additional capacity of 629,000kW installed by the end of September, 1954, with satisfactory prospects of another 75,000kW being added by March, 1955. As provision has been made for 1,330,000kW of installed capacity to be added by March, 1956, about 626,000kW of power will have to be installed within a year. It is feared that, owing to a number of difficulties, it may not be possible to keep to this schedule, but the target might be reached by the first year of the second Plan.

Despite this lag in planned development, good progress has been achieved so far. India has almost doubled the generating capacity in the public sector within eight years, from 1,250,000kW in 1946 to approximately 2,500,000kW by the end of 1954. In the private sector also about 300,000kW of new capacity has been added since the close of the war. Production from public supply undertakings (including State and private undertakings) has gone up from 3890 million kwh in 1946 to about 7340 million in 1954. Comparison with pre-war times is even more striking. In 1939 the undertakings, with an installed capacity of 1,100,000kW produced 2110 million kWh, less than a third of last year's production (Table I). It is clear from the figures in Table I that the average annual load factor since the war has been much higher than the pre-war figure.

Table I—*Power Production in India*

Year	Installed capacity (end of the year) million kW	Power production, million kWh
1939	1·104	2110
1946	1·250	3890
1950	1·712	5108
1951	1·835	5852
1952	2·061	6125
1953	2·320	6697
1954	2·5 (approx.)	7340 (approx.)

The second plan, now being worked out by the Planning Commission, is expected to be more ambitious, with at least 2,500,000kW of installed capacity to be added as compared with 1,330,000 during the first plan. A number of schemes which were begun in the early 'fifties will reach completion only in the second plan. For instance, the Bhakra dam is still in preliminary stages of construction and its 600MW will not be available for at least five years to come. Another big river valley project, the Koyna Valley project in Bombay, will also be reaching the close of its first stage by 1958 or thereabouts, and meanwhile a new thermal station near Bombay will make up the increasing demand in the growing industrial city of Bombay. By the end of 1960, therefore, India will have quadrupled her power production from about 4000 million kWh in 1946 to over 16,000 million kWh in 1960, assuming the present load factor to continue over the fourteen-year period. It is said that the expansion in generating capacity visualised in the first three five-year plans is of the order of 8,700,000kWh. If this schedule is maintained India will have increased her capacity eightfold in less than twenty years from 1946.

* Rs. 1 crore = £750,000.

Electrical Manufacture

This spurt in power production has had its effect on the electrical manufacturing industry in the country. Before the second world war India made such electrical goods as dry and storage batteries, certain kinds of wires and cables, fans, lamps, &c., but the growth of electrical manufacturing is mainly a wartime and post-war development. Production of electric motors, for instance, has gone up from 46,000 h.p. in 1946 to 187,000 h.p. in 1954, and that of power transformers from 40MVA to 398MVA during the same period. Many of the industries have to depend for some of the vital raw materials on imports, but attempts are being made to produce these indigenously. Most of the industries have been widening both their capacity and range of production. The electric motor capacity has increased from 60,000 h.p. in 1946 to 200,000 h.p. in 1954. Production also has expanded, but it is largely confined to motors up to 30 h.p. Import of three-phase squirrel-cage and slipring motors is restricted to assist the industry, which is now preparing plans to increase the range to 150 h.p. In 1952 the restriction of imports was brought forward to 50 h.p. The demand continues to rise and, according to an estimate of the Planning Commission, it will be 320,000 h.p. by 1955–56, 20,000 h.p. more than the present installed capacity.

The production of power transformers has increased tenfold since 1946. The industry is now widening its range and producing equipment up to 2000kVA and 11kV. Transformers up to 3000kVA were manufactured for the first time in 1954, which also saw the first 120 h.p. motor being made in India. In 1954 the industry actually produced more equipment than its installed capacity, which, at 300,000kVA, falls seriously short of the country's requirements. An idea of the scope of the transformer industry in India can be obtained from the fact that the

Table II—*Manufacture of Electrical Machinery and Equipment*

Item	1946	1950	1951	1952	1953	1954
Bare copper conductors (tons)	7,860	5,676	3,000	5,928	7,368	7,576
Conduits (thousand feet)	—	2,966	3,970	3,695	3,715	5,983
Domestic refrigerators (numbers)	—	—	—	600	1,140	1,013
Dry cells (million)	0·88	1·381	1·434	1·302	1·484	1·486
Electric fans (thousand)	110	193	212	196	199	236
Electric motors (thousand horsepower)	46	82	143	157	163	187
Fluorescent lamps (thousand)	—	—	—	76	102	214
Incandescent filament lamps (thousand)	8,114	14,304	15,516	20,804	19,666	22,860
House service meters (thousand)	—	—	—	34·4	80·7	148·8
Power transformers (thousand kVA)	40	172	196	215	308	398
Rubber-insulated cables and flexibles (million yards)	22·6	34·0	41·2	32·9	48·5	62·7
Radio receivers (thousand)	—	44·3	82·8	71·5	56·3	58·6
Winding wires (tons)	216	252	300	396	228	318

Table III—*Imports of Electrical Machinery and Equipment*
(Value in millions of rupees)*

Item	1946–47	1950–51	1951–52	1952–53	1953–54
Control and switchgear	11·59	37·02	43·93	54·83	56·97
Electrical instruments (other than telegraphic and telephonic)	5·71	8·09	13·13	8·79	7·45
Electrical instruments (telephonic and telegraphic)	3·86	10·95	3·74	3·85	4·88
Electrical wires and cables	16·18	41·17	34·38	77·04	71·90
Generators	9·38	15·63	29·39	24·63	40·83
Motors	9·58	14·10	11·49	12·29	14·37
Transformers	4·29	15·35	17·78	14·42	19·42
Turbo-generating sets	2·24	6·47	15·24	12·95	7·65
Other machinery	14·62	31·41	58·14	52·32	49·51
Total imports of all kinds	111·29	216·66	284·29	309·63	319·17

* 1 million rupees = £75,000.

Tariff Commission in its report has shown the need for an additional capacity of 2650MVA to utilise the additional power of 1334MW to be developed by 1956. Most of the requirements will therefore have to be met from imports, which have shot up from Rs. 0·134 crores in 1946 to Rs. 1·94 crores in 1953–54.

This rise in imports is common to most kinds of electrical machinery and apparatus. The accompanying tables indicate the extent of the growth of electrical manufacture and imports : the latter have risen from about Rs. 41 lakhs† in 1944–45 to about Rs. 320 lakhs in 1953–54. The bulk of the imports have come from Great Britain, but Swiss, German, Swedish, Belgian, and, more recently, Japanese concerns have been making significant headway in the export business. Most of the plant for the great river valley projects has been supplied by American firms (Westinghouse at Nangal dam, General Electric at Bokaro), but Japanese manufacturers have also been tendering successfully, a notable instance being the hydro plant at Tilaiya (Damodar). The 100MW station at Trombay will receive German equipment. Many of the high-voltage transformers are being supplied by Belgium and Sweden.

For a number of years to come heavy electrical plant of foreign manufacture will be needed for the river valley projects and the extension of the national and State grids. The home industry, despite the tremendous progress since the war, is still in its infancy and will have to store up a lot of experience before serious attempts at the manufacture of heavy equipment can be made on a large scale and with fair hopes of success. In this connection a new development is the projected heavy machinery factory, which the Government intends to set up in the near future with the technical and probable financial assistance of foreign manufacturers, whose report is now in the Government's hands. The Government's entry into the electrical manufacture field, hitherto strictly a private enterprise affair, has aroused ill-feeling from the existing concerns who were laying plans for such an eventual expansion of their activities. However, none of the present manufacturers could possibly have set up the plant without State assistance or aid from the World Bank. The projected Government factory will also make such equipment as transformers and motors of low rating.

As stated earlier, a number of raw materials have to be imported from abroad and unless the mechanical industries are able to keep pace with the needs of the electrical industry, the position may not show any improvement. Many of the materials such as sheet steel and copper conductors will now be made in the country in sufficient quantities to meet the demand, but several others still lag behind in production. Another factor militating against indigenous production is the generally prevalent prejudice against home goods. The Manufacturers' Association is making a concerted effort to fight it through better publicity, a general toning up of production and design standards, and stricter adherence to quality control. The Indian Standards Institution is also devising measures to enforce its standards and specifications. But the prejudice has an essentially psychological basis, which can be counteracted only through sustained quality production and the fostering of unimpeachable business integrity.

WETTING AGENTS IN EXTINGUISHERS.—Details have been received regarding the "Model 2301" extinguisher made by Nu-Swift, Ltd., Elland, Yorkshire. This is identical with the firm's 2-gallon universal (RN) extinguisher, "Model 1301," except that it incorporates a plastic bag containing a non-ionic wetting agent, besides the normal carbon dioxide propellant. On putting the extinguisher into operation the carbon dioxide pressure mixes the wetting agent with the main water charge, with the effect that surface tension is reduced and the water penetrates more readily to the seat of the fire. The wetting agent itself is non-corrosive ; nevertheless storage in a plastic bag has been adopted because otherwise its cleaning action on the metal surfaces of the container could lead over a long period to corrosion by the water. The bag can be inserted in the standard model, and its use is stated to be safe on electrical equipment up to 500V. It must not, however, be used in combination with an antifreeze.

† Rs. 1 lakh = £7500.

Continental Engineering News

O.E.E.C. Inquiry into Automation Problems

The use of automatic production control processes and the progress made in the manufacture of electronic computers have recently been investigated, under the auspices of the O.E.E.C. European Productivity Agency, by a group of European technicians, sociologists and trade unionists. The group decided to inquire into these problems among member countries of the Organisation. These countries have been asked to report during the next three months both on the present application of automatic techniques within their industries and on the prospects which these techniques seem to open up. The group will then arrange an international symposium, to be attended by experts on the technical, economic and social problems which are raised by automation.

The group's discussions have shown agreement that automation merely continues a tendency which has been present since the beginnings of the industrial revolution. The more recent electronic computers have, however, opened up possibilities in the field of statistics and operational research which were previously quite unthought of. The group considered that the various techniques covered by the term "automation" are of interest not only to heavy industry and mass production, but to all industrial and commercial firms, and perhaps particularly to those engaged in banking and insurance.

Trends during the past five years have shown, however, that automation is being introduced only very gradually, owing to the heavy investments required. This, it is thought, will give time for both management and labour to adapt themselves to the new techniques. On the basis of the current inquiry, the European Productivity Agency will be able to advise those in responsible positions on the technical, social and economic problems which are involved.

Swedish Subterranean Steam Power Plant

Blasting operations have begun at Stenungsund, near Gothenburg, for a subterranean power plant which is being built by the Swedish State Power Board. The station, said to be the largest of its kind in the world, will house four turbo-alternators, each of 150,000kW capacity. An order for the first set has recently been placed with STAL, of Finspong. The four sections of the Stenungsund plant, each consisting of a turbo-generator set and a boiler, will be housed in separate work chambers, measuring 330ft by 80ft by 100ft. The boilers will be fired with heavy oil, which will be unloaded directly from tankers into large cisterns blasted in the rock, a pier capable of receiving tankers of up to 40,000 tons forming part of the scheme. Protection against atomic bombs will be obtained by having a roof thickness of 300ft of solid granite. Operation of the plant will be almost entirely automatic. Scheduled to come into operation in October, 1959, the plant is estimated to cost £19,500,000, only 10 per cent more than a plant of the same size erected on the surface. The Swedish State Power Board and the A.S.E.A. electrical company are at present investigating the possibility of an atomic power station which would also be housed in the rocks at Stenungsund.

Standardisation of Screw Threads

At the recent meeting in Stockholm of the International Standardisation Congress, preliminary recommendations were adopted for reducing the number of threads now in use for screws below 6mm diameter, from fifty-four varieties to seven. Each of the present threads, it was stated, was used with over 2000 kinds of screw, the total number of designs thus being over 100,000. This number under the new proposals would, therefore, be reduced to some 14,000. The subject had previously been discussed at the 1952 I.S.O. congress in New York.

As regards larger screws, a compromise regarding sizes was reached between the millimetre countries and the inch countries. Instead of a 6mm diameter, 6·3mm is now proposed as corresponding more nearly to ¼in, while 8mm and 10mm screws are to be substituted for the current fractional inch sizes. These recommendations will have to pass through a number of working and technical committees before they become standards, but it is hoped that a definite solution will be reached before the Congress convenes again in three years' time.

German Industrial Research

In order to facilitate the placing of research contracts, the "Vermittlungsstelle fuer Vertragsforschung (VfV)—agency for sponsored research—was formed this year by the Arbeitsgemeinschaft Industrieller Forschungsverein Gungen, the Bundesverband der Deutschen Industrie, Deutsche Forschungsgemeinschaft, Deutscher Industrie-und-Handelstag, Deutscher Verband Technisch-Wissenschaftlicher Vereine, and the Stifterverband fuer die Deutsche Wissenschaft. The VfV is available equally to individuals, organisations and firms, and will advise those interested as to the best means available for carrying out specific projects of industrial research. It will act as intermediary between those seeking assistance and the various research institutes, which may be those attached to the universities, the Max-Planck group of institutes, or institutes maintained by the State. In the same way it will contact private research establishments and individual research workers. It is hoped that this will lead to greater use being made by industry of scientific research in order to solve those problems which the individual firm cannot tackle without prohibitive delays and expenditure. The VfV stresses the fact that all its employees are contractually pledged to maintain secrecy with regard to their work and that all preliminary negotiations are conducted without divulging the identities of prospective sponsors. According to the VfV proposal the legal status of the research body would be that of "employee-inventor." This should ensure that research workers are mentioned by name and share personally in any financial success. Research institutions, it is felt, will benefit from a better acquaintance with the problems of industry and would normally be able, subject to trade secrets being kept, to publish the scientific results of their work.

Swedish Oil Consumption

During the period 1946–1954 the aggregate civil consumption of liquid fuels in Sweden rose from 1949 million to 7104 million litres annually, an increase of 265 per cent. It now totals 1000 litres per inhabitant per annum, a figure exceeded only by Canada and the United States. The increase is mainly accounted for by a rise in the use of oil for heating, for which the present annual consumption is 4781 million litres, an increase of 360 per cent. In spite of a heavy increase in the number of motor vehicles during the last ten years, petrol consumption has risen by only 125 per cent to 1404 million litres per annum. About 11 per cent of the total consumption last year was sold by the "OK" Oil Consumers' National Association, a consumer-co-operative formed in 1945.

Second International Fiani Congress

The Fédération Internationale d'Associations Nationales d'Ingenieurs (Fiani) will hold its second international congress in Zürich from October 2 to 14, 1956. The theme of this congress will be "The Engineer in Europe," which will be dealt with from three points of view : (1) the full benefit from technological and industrial progress can only be obtained through a united Europe, without political or economic frontiers ; (2) science and technology know of no frontiers. Being engaged in both, engineers even more than other people have a duty to work at the European tasks which come within their province ; (3) the solution of many international problems (such as recognition of qualifications in all countries, unhindered exercise of profession, exchanges of personnel, freedom to carry out research and to exchange information) can only come about in a united Europe through the agency of suitably empowered institutions with which engineers everywhere should co-operate. The address of the Federation is 19, Rue Blanche, Paris (9e).

Industrial and Labour Notes

Coal Price Increases

Last week in this section we noted a letter on the subject of coal price increases, sent by Sir Norman Kipping, the director general of the Federation of British Industries, to the chairman of the National Coal Board. Sir Hubert Holdsworth, the chairman of the N.C.B., in replying to that letter, stated that the Board shared the regret of the F.B.I. that the substantial increases in coal prices should be necessary, but it considered that there could be no justification for selling coal at less than its average cost of production. There were, he said, four main reasons why costs have increased and were increasing, namely, the effect on the coal industry of rising wage levels and prices in the economy generally; the heavy losses already incurred (and certain to be incurred in future) on importing coal for the benefit of the general economy, and in particular to maintain industrial producuvity; rising interest and depreciation charges on the Board's growing capital development programme; and increased expenditure on measures designed to promote safety and health in the mines, particularly arising from the provisions of the Mines and Quarries Act, 1954. The increases in coal prices were thus strictly related to increases in costs which had already occurred, or which appeared to be inescapable.

Sir Hubert pointed out that in his article on "Replacing Lost Capacity" in the *Fuel Economy Review*, 1955, he had tried to explain why the results of reconstruction were slow to appear. In an extractive industry considerable capital expenditure was continuously necessary to replace lost capacity. Each year the Board had to plan to replace as much as 4,000,000 to 5,000,000 tons of productive capacity merely to maintain, let alone increase, production. The Board was endeavouring in ten years to cover forty years of normal reconstruction work, to provide indeed within the space of ten to fifteen years an 80 per cent new industry. In considering the figures of aggregate output from year to year this vital need to maintain capacity must not be overlooked. The larger capital schemes took up to ten years to complete and to work up to their planned output level. Of the seventy-four schemes approved and in progress, only four were completed by the end of 1954, and, states Sir Hubert, it will still be several years before many of these seventy-four schemes yield their results. Meantime, capital charges were being incurred and must be recovered from the consumers of coal.

Over the past eight years output and productivity had increased; the increase in productivity, as measured by output per manshift for all persons employed, had averaged 2 per cent per annum cumulatively.

United Kingdom Overseas Trade

The report on this country's overseas trade in the *Board of Trade Journal* shows that the dock strike of October, 1954, caused a severe distortion in the monthly figures of both the export and import trade of the United Kingdom, which persisted—particularly on the export side—in the first quarter of 1955. The further dock strike lasting from May 23rd to July 3rd and other strikes affecting the movement of goods in the same period have considerably affected the trade figures for June and, it is said, will undoubtedly continue to do so for some months to come. For this reason analysis of the trends in United Kingdom trade by comparison with preceding months and with the previous year has been rendered virtually impossible, and is likely to remain so until the effects of the latest strike can be considered to have worked themselves out.

The figures given show that the United Kingdom exports in June amounted to £157 million. This was £90,000,000 (or 36 per cent) lower than the average for April and May. June exports might normally be expected to be slightly lower, but nearly all the fall must be attributed to the strike. Total exports in the second quarter were 12 per cent below the first quarter, but this comparison is affected not only by the reduction caused by the dock strike in June, but also by the carry over from the October dock strike, which helped to raise the first quarter's figures. Total exports in the first half of 1955 were 3½ per cent above the first half of 1954.

This country's imports in June amounted to £294 million, or 1 per cent higher than in May, and the total imports in the second quarter of the year were 11 per cent lower than in the first quarter. Imports in the first half of 1955 as a whole, however, were 14 per cent higher than in the first half of 1954. Re-exports in June at £8,100,000 were about the same as in April and May, but over £2,000,000 less than the monthly average in the first quarter of the year.

Training for Management in the Iron and Steel Industry

Last April a sub-committee presented to the executive committee of the British Iron and Steel Federation a report on training and education for management in the iron and steel industry. The specific recommendations for action to be taken by the Federation given in this report were approved and it was agreed that the report should be issued as a general guide to companies in the industry, to be interpreted in the light of the particular circumstances of the firms. This report was recently published and it provides a general survey of the problems affecting education and training for men likely to become departmental managers in the industry. It examines the methods for furthering their training in works, courses available outside the works, and contains specific recommendations affecting individual companies and the training committee itself. On the subject of selection it is recommended that this should be based upon a systematic estimate of the company's future requirements and is the prerequisite of successful management development. Managers must, it says, always be on the lookout for men who have the necessary qualities but who have been overlooked by the normal selection procedure; furthermore, it should be made quite clear that selection for training is in itself no guarantee of promotion. On the subject of training and education it is recommended that the company's policy of recruitment and the methods of training and education should be widely understood and be flexible enough to deal with the late developer. Other recommendations deal with consultation with universities, release from work, courses and the responsibilities of management in ensuring satisfactory training.

On the subject of action to be taken by the Federation itself the sub-committee recommends that the Training Committee should undertake a study of the whole question of selection, and at suitable intervals appoint special committees to review the facilities which exist for advanced technical courses on specialised subjects. There should also be organised by the Federation a series of experimental courses for suitable men with the necessary experience on lines described in the report.

Remploy, Ltd.

In the course of a debate in the House of Commons on the recent cuts in recruitment and expenditure of Remploy, the Minister of Labour stated that further changes are being made in the board of this Government sponsored organisation for industrial training of disabled people. Answering criticisms of the cuts made in the Government grant, the Minister said that whilst the problem of the disabled had to be looked at from the human angle it had to be regarded as a financial problem as well. In connection with the reduction in capital expenditure the company had called for a report from two experts in the Ministry of Labour and also for one from the organisation and methods department of the Treasury. A full report had been received and was now being considered by the company. In the first talks between the Ministry and the company in the light of the reports the problems raised included matters of reorganisation, financial control and changes in the board. To strengthen the board the Minister had got Mr. A. T. S. Zeally, a former director of I.C.I., to agree to become chairman of the company next year, and Mr. George H. Dowty to join the board.

Labour Disputes in May

The *Ministry of Labour Gazette* shows that 257 stoppages of work arising from industrial disputes were reported to the department at the beginning of May; there were also nine stoppages in progress which started before May. As a result of these 266 stoppages, it is estimated that nearly 202,000 workers were disengaged, and the aggregate number of working days lost during the month was about 838,000. The number of days lost in the period January to May, 1955, through stoppages which began in that period was 1,387,000, the number of workers involved in such stoppages being 389,100. In addition, 40,000 days were lost at the beginning of the year by 12,400 workers through stoppages which had begun towards the end of the previous year.

Iron and Steel Prices

The Iron and Steel Board announced increases in maximum prices which took effect on July 25th over the whole range of iron and steel products in respect of which these are determined by the Board. In making the announcement it is pointed out that the cost of production has been affected by increases in various items, notably the higher price of coal; the increase in the landed cost of imported materials; the increase in railway rates announced in May, and the general wages increases which have recently been negotiated within the iron and steel industry itself. The Iron and Steel Board considers that the margins for depreciation, obsolescence and profit determined at the end of last year following the Board's comprehensive review of the price structure were those necessary for the maintenance of a healthy and expanding industry. It states that although, as a result of increased production and efficiency, it is possible for the industry to absorb some part of the increases in cost, the greater part must now be reflected in the prices of iron and steel products if the Board's objectives are to be maintained.

The incidence of the increased costs is unequal, and generally speaking the price adjustments are proportionately greater in relation to prices of the less highly processed material than in the case of more highly finished products. The range of prices increases for materials are as follows:—Basic pig iron, 7 per cent; foundry pig iron, 9½ per cent; semi-finished steel, 6½ per cent; heavy steel products (plates, joists, sections, rails), 5¾ per cent; hot rerolled products, 5½ per cent; sheets, strip mills, 4½ per cent; sheets, hand mills, 6½ per cent; tinplate, strip mills, 2¾ per cent; hand mills, 5½ per cent; hot finished tubes, 5½ per cent. The new prices, it is stated, are approximately 15 per cent below American and Continental prices.

Monopolies Commission

It is announced that in accordance with the provisions of the Monopolies and Restrictive Practices Commission Act, 1953, the chairman of the commission has appointed a group to consider and report on the supply of electronic valves and cathode-ray tubes. The members of the group are as follows: Sir David Cairns, Q.C., chairman; Professor G. C. Allen; Mr. J. Archdale; Mr. W. G. Cullen; Mr. C. N. Gallie; Mr. C. H. P. Gifford; Professor A. L. Goodhart; Mr. Gordon Stott, and Mr. C. E. Wrangham. It was announced on December 8, 1954, that the subject in question had been referred to the Commission by the Board of Trade. Written and oral evidence is now being taken from manufacturers, wholesalers, retailers and others interested in the trade. Any inquiries, and any offers to give evidence to the commission should be addressed to the Monopolies and Restrictive Practices Commission at 8, Cornwall Terrace, Regents Park, London, N.W.1.

Folsom Dam in California

BY OUR AMERICAN EDITOR

THE first of three 60MVA turbo-generators at the Folsom dam power station in California went into commercial operation in May. The Folsom dam is situated on the American River near Sacramento, and while this structure is of considerable importance from a local flood-control, irrigation and power generation point of view, it is of even greater interest as the first major case of co-operation between the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. In this particular case, the dam is being constructed by the former and the power station by the latter body. The Folsom dam, which is shown under construction in the accompanying illustration, is creating a reservoir with a gross capacity of 1,000,000 acre-feet. Of this, about 88,000 acre-feet will be utilised to maintain a minimum power pool while the remaining 912,000 acre-feet will be operated in the joint interest of flood control, municipal and industrial water supply, irrigation, power and incidental recreational uses. The maximum flood-control reservation, which will vary seasonally with the flood hazard, will be 400,000 acre-feet. The Folsom power turbines will have a gross head ranging from 196ft to 336ft, and an installed capacity of 162MW. The concrete river section of the dam is founded on fresh granite rock. The earth wing dams and eight of the saddle dykes are, in general, founded on decomposed granitic soils, their cut-off trenches being taken down through surface soils of relatively light density to weathered but firm granite.

The maximum height of the concrete river section of the dam, from foundation to roadway, is 340ft and the combined length of the concrete overflow and non-overflow sections is 1400ft. About 960,000 cubic yards of excavation and 1,170,000 cubic yards of concrete were required for the concrete dam and its stilling basin. All sections of the dam were designed as vertical gravity sections 1ft wide, under various assumptions as to pool and tailgate elevations, uplift and earthquake loading. Each of the eight Tainter gates on the spillway crest is operated by its own individual motor-driven hoist. The five-bay river spillway section has four 5ft by 9ft combination flood control-irrigation sluice outlets in each of two tiers. Each sluice is controlled by two 5ft by 9ft hydraulically operated slide gates in tandem, one acting as the service gate and the other as an emergency gate. An 8ft by 15ft fixed-wheel face gate is also provided to unwater the sluices for inspection and maintenance. An operating bridge and roadway are provided over the spillway section, and rails extend across the concrete dam for a gantry crane to operate the face gate and the penstock emergency gates.

On the axis of the dam, the low water width of the river is limited to about 250ft. Hydrologic and hydraulic studies by the Corps of Engineers indicated that, to protect the dam from overtopping under an extreme, but theoretically possible combination of events, the spillway should have eight Tainter gates, 42ft wide by 50ft or 54ft in height. In the narrow river channel, only five 50ft high gates could be economically provided with a conventional hydraulic jump stilling basin. The other three gates, 54ft in height, are situated on the left abutment immediately adjacent to the main spillway section. These three gates have no provisions for dissipation of energy, but do incorporate a "flip bucket" near the toe of the dam, so that, if and when they go into operation, the impact of the spilling water will not endanger the safety of the dam. Operation of these gates would be a rare event in any case, as even without considering the reduction of a peak by storage or surcharge, the five main gates alone can pass an uncontrolled peak inflow of about 300,000 cusecs, which theoretically may be expected only about once in 500 years.

The stilling basin has been designed to prevent objectionable surges in the vicinity of the power plant for flood control releases up to 115,000 cusecs. Three 15ft 6in diameter steel-lined penstocks, which are controlled by fixed-wheel emergency gates, pass through the right abutment non-overflow section to serve the power plant. The concrete river section is enveloped on both ends by large earth wings having a maximum height of 145ft, a combined length of 9000ft, and a combined volume of about 7,800,000 cubic yards. Both wing dams incorporate an impervious core with a pervious shell, separated by a transition zone of processed materials, where necessitated by grading requirements. The cut-off trench backfill and the impervious zone consist of compacted decomposed granite, while the pervious shells consist of natural river gravels, dredge tailings, and surplus rock from excavation. Riprap protection, from rock obtained from excavation, is provided on the water face of the wing dams. Their crest width is 30ft, and their downstream and upstream slopes are 1 in 2 and 1 in 2¼ respectively. The sections were designed by the circular arc method of analysis with earthquake loading considered.

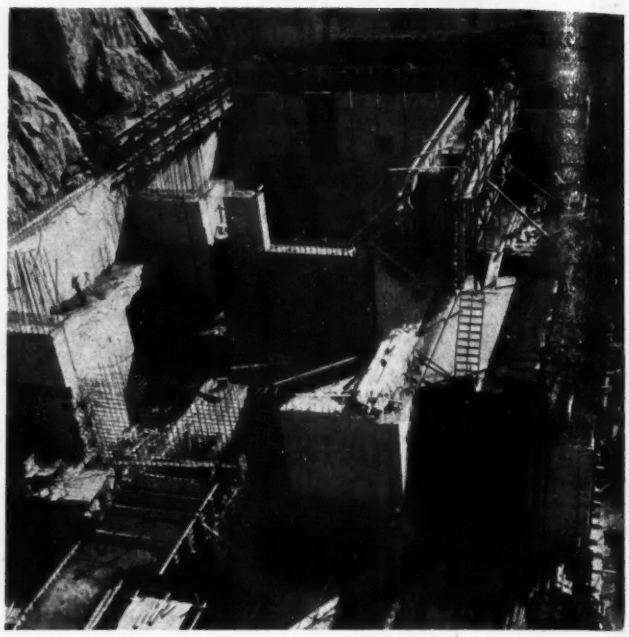


Fig. 2—Power station of Folsom dam in California under construction

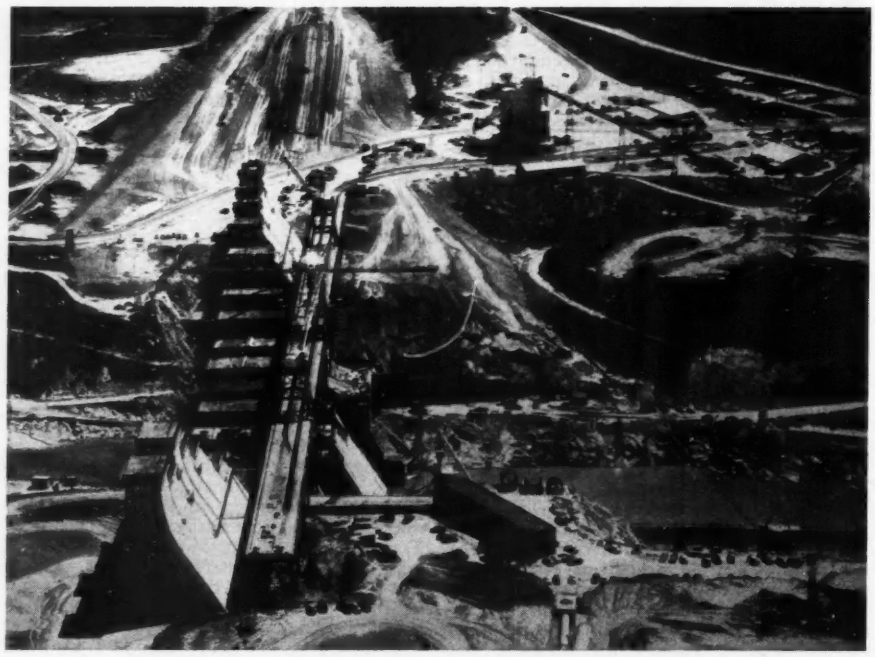


Fig. 1—Aerial view of main concrete section of Folsom dam under construction in California

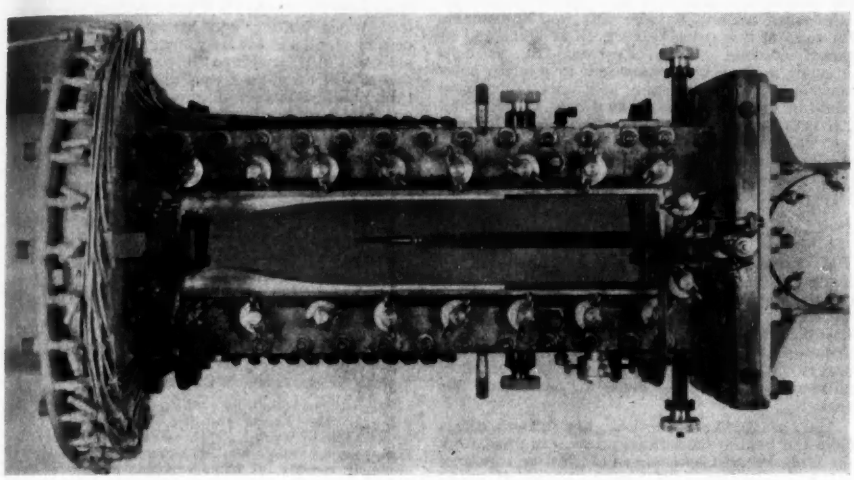
The construction of the concrete section of the Folsom dam presented several foundation problems. The exploration of the site was difficult because of the weathered and jointed condition of the rock. Before the main dam contract was awarded, extensive exploration was carried out by core borings, and two preliminary excavation contracts were executed. These carried foundation excavation close to the expected final foundation line on the two abutments. In spite of these precautions, during construction of the main dam a number of flat-dipping weathered zones, on which some movement had taken place in the past, were encountered in the left abutment foundation area of the concrete river section. These zones varied in thickness from a few inches to as much as 3ft, contained some residual as well as ground-water-deposited clays, and in general dipped toward the river 15 deg. and slightly upstream. They created a time-consuming problem which was solved by removing all overlying rock down to the foot wall of the lowest fault zone.

With regard to concrete production, aggregate from the natural gravel and dredged tailings in the American River about 4 miles downstream from the dam site had been determined to be of satisfactory quality. Because of the design requirement that concrete be placed at or below

50 deg. Fah., it was necessary to install a large refrigeration plant with a capacity of about 1000 tons of ice per day. The concrete sections of the dam were high enough for water storage by the dam to commence recently. It is expected that the entire structure will be completed toward the end of this year. The power station is situated on the right bank of the river, 550ft below the dam, and is shown under construction in the accompanying illustration. Its power plant has been designed for a rated operating head of 300ft and its output is being fed into the grid of the Central Valley Project of the U.S. Bureau of Reclamation.

Hot-Wire-Anemometer Measurements in Supersonic Flow

IN recent years the development of high-speed jet and rocket-powered aircraft has stimulated extensive research into supersonic phenomena affecting aeronautical design. Beyond the sonic barrier conditions and forces encountered in air flow are very different from those experienced at lower speeds, and in all studies of fluid flow the chaotic motions known as turbulence play an important part. The mixing action of turbulence is known to be one of the controlling factors in the maximum life of an aircraft wing, and is also one of the factors contributing to air friction on the aircraft. Within the subsonic range the hot-wire anemometer, which, essentially, is a very fine electrically heated wire whose resistance changes with air cooling, has been widely used in wind tunnel studies of turbulence. However, until recently there had been no well-defined method of studying turbulence at air speeds exceeding that of sound.



Test section of N.B.S. supersonic wind tunnel with hot-wire probe mounted centrally

In an effort to extend the range of the hot-wire anemometer into the supersonic region the National Bureau of Standards, of Washington, D.C., recently conducted a study of the behaviour of this instrument at air speeds up to twice the speed of sound. Sponsored by the National Advisory Committee for Aeronautics, the investigation covered a wide range of speeds, air densities, and wire temperatures for wires of different sizes set at various orientations to the stream. In this way new possibilities in the application of the hot-wire anemometer to aerodynamic studies were found. The results, obtained in combination with those found by other laboratories, indicate that the device is of potential value as a tool for research on turbulence at high speeds. The ability of the hot-wire anemometer to respond to rapid variations in velocity has made it useful for many years in measuring turbulence at low subsonic speeds in terms of the magnitude and frequency of velocity fluctuations. However, at high subsonic and supersonic speeds the situation is much more complex than at low speeds. The frequency range of the instrument must be extended from about 10,000 c/s to the order of 100,000 c/s. Furthermore, because of compressibility effects and the expenditure of large amounts of power in supersonic wind tunnels, fluctuations of density and temperature occur together with velocity fluctuations. All of these factors contribute in one way or another to the aerodynamic behaviour of a model in a supersonic wind tunnel, and to a degree yet unknown, to the behaviour of bodies in flight. The object of the investigation at the National Bureau of Standards was to determine the response characteristics of the hot-wire anemometer to all of the known variables associated with turbulence at high speeds.

The experimental work was carried out in the N.B.S. supersonic wind tunnel, which is of the continuously operating, variable-density design, with a 3in by 4in test section. This test section is shown in the accompanying illustration with the hot-wire probe mounted centrally. The stagnation pressure, or pressure in the reservoir preceding the test section of the tunnel, may be varied from ¼ to 2½ atmospheres, and its temperature may be set at any value between 70 deg. and 140 deg. Fah. The free-stream density and velocity and wire diameter were varied independently over the widest possible range so that the part played by each in heat loss could be determined. However, since supersonic flow does not permit the velocity at a given Mach number to be varied without varying the free-stream temperature, the effects of Mach number, free-stream velocity, and air conductivity could not be evaluated independently. To reduce the number of variables all tests were run at a constant stagnation temperature. The values of free-stream density, Mach number, viscosity, and conductivity were computed for supersonic flow from the measured stagnation pressure, pressure differential between stagnation and test section conditions, and stagnation temperature.

Because of the high frequencies anticipated at supersonic speeds, wires as small as 0·00005in in diameter were studied. The wires were made of platinum, tungsten, and platinum-rhodium; their diameters ranged from 0·00005in to 0·0015in. The Bureau experimented with several hot-wire probes in an effort to find a design sufficiently rigid to withstand the stresses and vibrational forces encountered in the transonic speed region and during the passage of the shock wave produced by starting and stopping the tunnel. In the design finally adopted the heated wire was attached to the ends of two honed sewing needles, 0·018in in diameter, which were butt-brazed to electrical leads embedded in hard rubber. To minimise the end-loss correction the spacing of the needles was usually selected to accommodate a wire about 3mm long. The wire holders were held by a chuck attached to a three-directional traversing shaft extending forward into the test section from a diamond-shaped strut farther downstream.

The evaluation of the heat loss from the wires required an accurate measurement of wire resistance and current. The unheated resistance was found by using a bridge current sufficiently small to avoid heating of the wire. The temperature rise of the heated wire was then determined from the resistance change and the temperature coefficient of the metal. The pressures and pressure differentials were measured with either vertical or inclined manometers, depending upon their magnitude, and temperature was measured with a mercury thermometer. The wire lengths were determined to the nearest hundredth of a millimetre with a travelling microscope. The accepted theory of incompressible flow indicates that the Reynolds number of the heated wire and the temperature difference between the wire and the ambient air are the principal parameters governing heat loss from the wire. This implies that air density and velocity and wire diameter are equivalent physical variables. However, the results of the present investigation indicate that in contrast to this accepted theory the heated wires respond differently to each of the factors contributing to the rates of cooling, such as the velocity and density of the air and the temperature and diameter of the wire, so that no simple relationship can be established.

It was found that wire diameter and air density were, in effect, equivalent variables, but that velocity or Mach number (the effects of which could not be separated) influenced the heat loss entirely differently. When density and wire diameter were held constant an increasing Mach number was accompanied by a decreasing sensitivity to velocity change. In fact, this sensitivity actually became negative under certain conditions as the speed of sound was approached in the subsonic region. These Mach number effects were found to be less at supersonic speeds, and they tended to disappear as a Mach number of 2 was approached. However, no data were obtained above this speed. It was also found that the heat loss did not vary directly as the temperature difference between the wire and the air. The heat loss per degree either increased or decreased with temperature loading, depending upon air density, Mach number, and wire temperature and diameter. Wires inclined to the wind direction showed heat losses dependent upon the component of velocity normal to the wire. They displayed supersonic characteristics in a supersonic stream only when this normal component was supersonic.

Nuclear Congress and Atomic Exposition

THE Engineers' Joint Council of America has announced that a Nuclear Congress and Atomic Exposition is to be held at the Municipal Auditorium in Cleveland, Ohio, from December 12 to 17, 1955. The Nuclear Congress represents the most important project jointly undertaken so far by the engineering institutions of the United States. The basic objective of the Congress is to launch a continuing programme of interchange of information on the developing applications of nuclear science by the engineer. The atomic exposition is being sponsored by the American Institute of Chemical Engineers and is intended to bring together under one roof all the major developments in industry and science related to atomic energy. This includes not only atomic power developments, but also the expanding applications of atomic by-products in various industrial fields. Suppliers to the various atomic industries are being invited to display their latest developments relating to peacetime applications of atomic energy.

Personal and Business

Appointments

MR. WALTER ALFRED CLARKE has been appointed production development manager at the German factory at Hanau of Dunlop, Ltd.

J. C. NEVILLE, Ltd., 34, Priests Bridge, London, S.W.14, announces that Mr. A. T. Scales, until recently sales manager, has now been appointed sales director.

DAVIDSON AND CO., Ltd., of Belfast, announces that Mr. H. Dunlop and Mr. C. E. H. Eckersley, M.I.Mech.E., M.Inst. F., have been appointed directors of the company.

JOHN I. THORNYCROFT AND CO., Ltd., announces that Mr. A. Davis has been appointed technical sales representative for the company's marine and industrial oil fuel burning equipment.

THE BRITISH PETROLEUM COMPANY, Ltd., announces that Mr. Charles Howard, who joined the company in 1922, has been appointed Engineer Commodore of the British Tanker Company's fleet.

MR. JEFFREY WATKINS, formerly with the performance department of D. Napier and Son, Ltd., has been appointed Senior Aerodynamicist of the Solar Aircraft Company of San Diego, California.

SHORT BROTHERS AND HARLAND, Ltd., announces the appointment of Sir James H. Barnes, K.C.B., K.B.E., who was until recently the Permanent Under Secretary of State for Air, as a director of the company.

W. G. ALLEN AND SONS (TIPTON), Ltd., Princes End, Tipton, Staffs, announces the appointment of Mr. G. Evans, "Rinconcillo," St. Martin's Road, Caerphilly, Mon, as the company's sales representative in the South Wales area.

THE METROPOLITAN WATER BOARD announces that Mr. S. D. Askew has been appointed clerk of the Board, as from August 20th. Mr. W. S. Chevalier, C.B.E., the present clerk, retires on that date, after forty-seven years of service with the Board.

THE INTERNATIONAL MEEHANITE METAL COMPANY, Ltd., 4, Downside, Epsom, Surrey, announces that Mr. P. Attenborough, Mr. G. Hobman and Mr. E. W. Harding have been appointed to the board of directors, with Mr. E. M. Currie as managing director.

MR. ERNEST F. THOMPSON, works manager of the Dowlais (South Wales) factory of the Small Heath Group of the B.S.A. Company, Ltd., has been appointed works manager of the Redditch (Worcs) factory, including the B.S.A. precision casting foundry.

MR. EDWIN FLETCHER has been appointed deputy director of the European Productivity Agency. Mr. Fletcher has been in charge of the British T.U.C. Production Department since its formation in 1950 and he has been given leave of absence to take the post as deputy director of the agency.

MR. ARTHUR DONALD BUSBY, B.Sc., A.I.M., who has been a member of the development and research department of the Mond Nickel Company, Ltd., for eighteen years, has resigned his position. As from September 1st, he is taking up the post of deputy process development manager of the titanium department, I.C.I. (Metals), Ltd., Witton, Birmingham.

MR. A. N. SAVAGE, M.I.E.E., electrical engineer superintendent of Royal Mail Lines, has been appointed by the council of the Institution of Electrical Engineers to serve in a personal capacity on the Committee on Regulations for the Electrical Equipment of Ships, which serves also as the United Kingdom Committee for Technical Committee No. 18 of the International Electrotechnical Commission.

Business Announcements

GARRINGTON'S, Ltd., states that the telephone number of its Albert Works, Darlaston, is now James Bridge 2711 (seven lines).

TUBE INVESTMENTS, Ltd., announces that on reaching retirement age, Major W. F. F. Scott, M.C., director of training and welfare, will retire from the Board and relinquish his appointments within the company on July 31, 1955.

THE SMALL HEATH GROUP OF THE B.S.A. COMPANY, Ltd., has recently taken over financial control of the Idoson Motor Cylinder Company, Ltd., Tividale, Staffs. No change of policy is envisaged and Mr. T. H. Taft will continue to serve as managing director.

PLASTER PRODUCTS (GREENHITHE), Ltd., has opened a London office at 55/56, Windsor House, Victoria Street, S.W.1 (telephone number Abbey 6500). Full technical service is available at this office, which is in charge of Mr. J. T. Freeman, the firm's senior technical representative.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING COMPANY, Ltd., announces the formation of a new wholly-owned subsidiary company, Brightside Heating and Engineering Company, Ltd., which has been formed to take over the continuously expanding activities of the firm's heating, air treatment and pipework division. Mr. Ambrose Firth has been appointed chairman and Mr. T. C. Firth, Mr. W. S. Richards and Mr. W. B. James, directors of the new company.

MAGNESIUM ELEKTRON, Ltd., announces that Major C. J. P. Ball, D.S.O., M.C., who has held the post of chairman and managing director from the company's formation in 1934, has relinquished the latter appointment in favour of Dr. C. J. Smithells, M.C., but remains as chairman of the company. Brigadier A. G. Cole, O.B.E., previously assistant managing director, has been appointed commercial director, and Dr. S. J. Fletcher remains technical director.

MR. C. A. MARTIN, M.I.E.E., consulting engineer to the British Thomson-Houston Company, Ltd., has retired after thirty-six years' service with the company. He is succeeded by Mr. G. M. McIlwrick, B.Sc. Hons., A.R.T.C., A.M.I.Mech.E., A.M.I.E.E. Mr. McIlwrick takes over Mr. Martin's work on standardisation, committee representation and interchange of information, and he has been elected to the British National Committee of the International Electrotechnical Commission.

BAKELITE, Ltd., announces the conclusion of an agreement with Union Carbide, Ltd., under which the firm will market polyethylene plastics produced in the United Kingdom by Union Carbide, Ltd. The sales organisation of Bakelite, Ltd., will be available for sales of this polyethylene both at home and in export markets. Union Carbide, Ltd., is constructing a plant at Grangemouth to produce polyethylene of the same quality and types as that now made in the United States by Union Carbide and Carbon Corporation. The plant is expected to come into operation in the third quarter of 1957, but in the meantime Bakelite, Ltd., will have available quantities of imported polyethylene for sales development purposes.

Contracts

SIR ROBERT MCALPINE AND SONS (CANADA), Ltd., has been awarded a contract valued at 1,250,000 dollars, by the Hydro-Electric Power Commission of Ontario. The contract involves re-routing the Canadian National Railway main line at Cornwall, Ontario, as required by the St. Lawrence seaway project. It involves the construction of 11 miles of railroad bed and is scheduled for completion this year.

MARCONI INSTRUMENTS, Ltd., has received orders from the English Steel Corporation, Ltd., and from the United Steel Companies, Ltd., for the supply of 250kV constant potential X-ray units to their works at Grimesthorpe and Distington, respectively. The equipment for Grimesthorpe comprises a constant potential high-tension generator, a control unit, an oil cooler, and an oil-cooled shockproof tube head with a special turntable mounting for fitment to a girder suspension system. The Distington equipment is electrically similar, but is mounted on a specially designed 2-ton trailer to facilitate radiographic inspection of welds and castings, irrespective of size. The control unit is installed in a lead-lined protective compartment, while at the opposite end is the tube head and tube stand. These equipments have a voltage range of from 30kV to 250kV, enabling steel of up to 4in in thickness to be penetrated. The constant potential generators enable the whole of the high-voltage energy to contribute to X-ray generation, ensuring maximum X-ray output and hence exposure times shortened by half.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received (through Australian General Electric Pty., Ltd.) an order valued at over £285,000 from the State Electricity Commission of Victoria. It covers a 20MW, 3000 r.p.m., low-pressure turbine-generator set for installation at the Commission's brown coal briquetting factory at Morwell. The set will include a double-flow, low-pressure turbine designed to use surplus exhaust steam from two Metropolitan-Vickers 30MW back-pressure turbine-generator sets already installed at the same station. Originally it was planned to use the exhaust from the larger turbines as process steam in the briquetting plant, but because of financial restrictions the construction of this plant will not go forward as quickly as anticipated; it was therefore decided to convert the resultant surplus steam into electrical energy which will be fed into the Electricity Commission's system. Approximately 420,000 lb per hour of surplus steam will be passed into the new turbine at 27½ lb per square inch gauge and 299 deg. Fah. The turbine will be coupled to an air-cooled a.c. generator designed for a power factory of 0·7; generation is at 11,000V, 50 c/s. Both the turbine and the generator will be made at the M.-V. Trafford Park works. The associated condenser, operating at a vacuum of 27½in Hg, and the feed water heaters will be manufactured to Metropolitan-Vickers design in Australia.

THE CENTRAL ELECTRICITY AUTHORITY has placed contracts during June for power stations, transforming stations and transmission lines amounting in the aggregate to £16,647,000. The principal contracts include:—Acton Lane power station, Willesden, demolition and foundations (Sir Robert McAlpine and Sons, Ltd.); Belvedere power station, main foundations, underbuilding and associated works (John Mowlem and Co., Ltd.), and two 7500kVA station transformers (Hackbridge and Hewittic Electric Company, Ltd.); Marchwood power station, near Southampton, two 550,000 lb per hour boilers (John Thompson Water Tube Boilers, Ltd.); Poole power station, foundations (George Wimpey and Co., Ltd.); Portishead "B" power station, near Bristol, ash and dust-handling plant (John Thompson Industrial Construction, Ltd.); Goldington power station, Bedford, steel frame for turbine house and boiler house buildings (John Booth and Sons (Bolton), Ltd.); Little Barford "B" power station, near St. Neots, two 60MW turbo-generators, feed water heating and condensing plants and one 72MVA. 141·6/11·8kV generator transformer (C. A. Parsons and Co., Ltd.) and two 550,000 lb per hour boilers (Foster Wheeler, Ltd.); Castle Donington power station, near Derby, one cooling tower (Mitchell Construction Company); Drakelow "B" power station, Burton-on-Trent, one 120MW reheat turbo-generator, feed water heating and evaporating plant, condensing plant, and auxiliary apparatus (C. A. Parsons and Co., Ltd.); Staythorpe "B" power station, Newark, two 60MW turbo-generators and feed heating plant (Metropolitan-Vickers Electrical Company, Ltd.), one 60MW turbo-generator (General Electric Company, Ltd.), and condensing plant for three 60MW turbo-generator sets and feed heating plant for one set (Worthington-Simpson, Ltd.); Willington "A" power station, near Derby, two reinforced concrete chimneys (Tileman and Co., Ltd.); Ocker Hill power station, Tipton, Staffs, main building and superstructure (Sir Alfred McAlpine and Son, Ltd.); Skelton Grange "B" power station, Leeds, boiler feed pumps (Sulzer Bros. (London), Ltd.); West Weybridge substation, 132kV switchgear (A. Reyrolle and Co., Ltd.); and Cardiff West-Pyle/Ebbw Vale, 132kV overhead lines (J. L. Eve Construction Company, Ltd.).

Miscellanea

MR. JOSEPH GARDNER.—We record with regret the death of Mr. Joseph Gardner, after a short illness at his home in Worsley. Mr. Gardner, who was in his eighty-second year, was a founder member of the company bearing his name and was actively engaged until his recent illness in carrying out his duties as chairman and managing director of L. Gardner and Sons, Ltd., and of the subsidiary company, Norris, Henty and Gardners, Ltd.

DEATH OF MR. P. MILEY.—It is with regret that we note the death of Mr. Percy Miley, chief draughtsman of Craven Brothers (Manchester), Ltd., Reddish, Stockport, for the past twenty-three years, on July 15th, after a short illness. Much of the earlier part of Mr. Miley's career was spent with this same firm and, among other executive positions held, he was for a period of six years the general manager of the machine tool department of John Hetherington and Sons, Ltd., Manchester.

RUGELEY "A" AND AGECROFT "B" POWER STATIONS.—The Central Electricity Authority has received the consent of the Minister of Fuel and Power to the establishment of a new power station at Rugeley, Staffordshire. It will be known as the Rugeley "A" power station and will have an installed capacity of 240MW provided by four 60MW turbo-generator sets each steamed by a boiler unit having an evaporative capacity of 550,000 lb an hour. Consent has also been received for the extension of the Agecroft "B" power station at Salford by two 120MW turbo-generator sets and two boiler units each having an evaporative capacity of 860,000 lb of steam an hour. This plant will increase the installed capacity of the station to 345MW.

ELECTRICAL SECTION OF B.I.F., 1956, AT OLYMPIA.—An electrical exhibition will be held in the Grand Hall, Olympia, London, from April 23 to May 4, 1956, as part of next year's British Industries Fair. There will be 100,000 square feet of exhibition space available for the display of a variety of electrical products, from power station and industrial plant equipment to lighting and domestic appliances. This will be the first time that the industry has been on show at the London B.I.F. since the Fair started in 1915. Although the electrical section will be at Olympia, those electrical firms who still wish to exhibit in Birmingham will be able to do so. The 1956 Fair is being held at two different times of the year—at Earls Court, London (light consumer goods), from February 22nd to March 2nd, and at Olympia, London, and Castle Bromwich, Birmingham, from April 23rd to May 4th. Technical products, such as chemicals, office appliances, scientific instruments and electrical equipment, will be on display at Olympia. The engineering and hardware section will be at Castle Bromwich, Birmingham.

British Patent Specifications

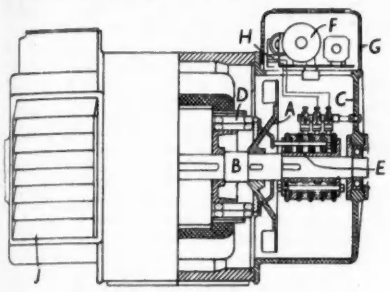
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

ELECTRICAL ENGINEERING

730,059. December 18, 1952.—ELECTRIC GENERATORS, Ludwig Peter Franke, of Wright Electric Motors (Halifax), Ltd., Century Works, Pellon Lane, Halifax; and Wright Electric Motors (Halifax), Ltd.

The invention relates to self-exciting electric generators which are provided with automatic voltage regulation. As shown in the drawing, a self-exciting electric generator is provided with a fan *A* mounted on the rotor shaft *B* inside the generator shell *C* and at the driving shaft extension end and situated on the shaft between the rotor winding *D* and the slip rings *E*. The shell or carcase of the generator is also provided with an automatic voltage regulator unit *F* mounted within a box *G* which is mounted at the fan end of the generator, and is provided with an opening corresponding to an opening in the generator shell *C*

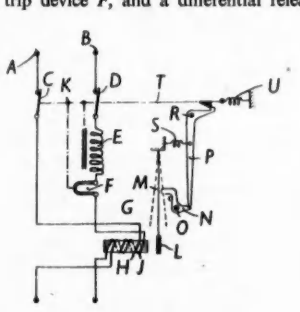


No. 730,059

so that the space inside the automatic voltage regulator box is connected with the space inside the generator shell. The arrangement is such that the carbon piles *H* of the automatic voltage regulator lie directly over the fan so that upon rotation of the generator shaft *B* a stream of air is directed radially from the fan over the carbon piles. Louvres *J* are provided in the generator shell at each side and by suitable regulations of these the supply of air to the cooling fan and thereby to the automatic voltage regulator can be varied. An advantage of this construction is that a constant supply of cooling air is provided so long as the unit is in operation. This is particularly important when the unit is required to operate in tropical conditions.—*May* 18, 1955.

732,159. March 11, 1953.—AUTOMATIC ELECTRIC CIRCUIT BREAKERS, Landis and Gyr A.G., Gubelstrasse, Zug, Switzerland.

The invention relates to automatic electric circuit breakers having differential releases. In the drawing *A* and *B* are two terminals of a circuit breaker which has the customary two movable contacts *C* and *D*, an instantaneous electromagnetic release coil *E*, a thermal trip device *F*, and a differential release *G*.



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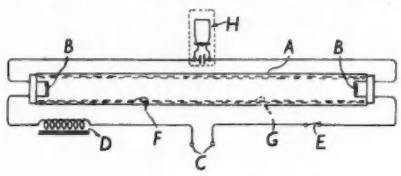
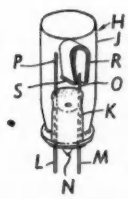
The latter bears two oppositely connected windings *H* and *J*, each lying in one of the two current paths of the breaker. The two contacts *C* and *D* are arranged to be released by the release coil *E* on the occurrence of a cable short circuit or by the thermal device *F* for a sustained overload, as represented diagrammatically by the broken lines *K*. A comparatively light armature *L* is suspended in the magnetic field of the differential release *G*, which may act through a relay, by means of a thin leaf spring *M* so as to be readily capable of oscillating. This action occurs whenever only one of the two normally self-neutralising magnetic fluxes in the differential magnet *G* varies and a resultant differential magnetic flux is set up which excites the armature *L* in the cadence of the mains frequency. With a small effective magnetic flux the amplitude of swing of the armature is initially only slight, but it builds up quickly. Beside the leaf spring *M* there is arranged a trip lever *N* mounted rotatably about an axis *O*, acting with a cutaway edge on a second trip lever *P* which is pivotally mounted on an axis *R* and is acted upon by a spring *S*. The second lever *P* co-operates with a cutaway edge provided on a mechanism *T* urged by a spring *U*. The circumstances are so chosen that the oscillating leaf spring *M* is able to release the trip lever *P* by swinging the trip lever *N*, whereby the contacts *C* and *D* are opened. Any form of release lever mechanism may be used that enables release to be effected by a comparatively small force. To render ineffective harmful stray fields, the two windings of the differential release are formed with wires lying parallel to each other and so arranged that they are traversed at all times by oppositely directed currents.—*June* 22, 1955.

730,807. November 27, 1952.—GLOW TYPE THERMAL ELECTRIC SWITCHES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2

The invention relates to thermal electric switches and in particular to switches comprising a thermally responsive element actuated by heat generated by a gaseous discharge. The upper drawing shows the wiring connections for an electric discharge lamp, including the new glow type thermal switch, and the lower view is a perspective view of the essential parts of the switch. The fluorescent discharge lamp is of the positive column electric discharge type with a tubular envelope *A* having the usual spaced activated thermionic cathodes *B* in its ends. They are specially heated





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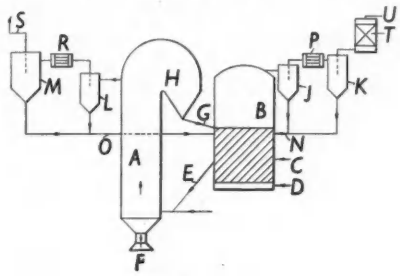
cathodes of the usual coiled filament and alkaline earth oxide coated type, and are shown connected across the terminals *C* of a power supply. The lamp circuit includes the usual ballast *D*, which also serves as a starting inductance, and the manual make-and-break control switch *E*. The envelope contains a low-pressure atmosphere of starting gas, such as krypton, a quantity *F* of mercury exceeding the amount that will vaporise during operation of the lamp and an internal coating *G* of fluorescent material or phosphor on the inner surface of the envelope wall. A starting and electrode heating circuit is shown connected to a terminal of each of the filamentary cathodes *B* and across the lamp with a starting switch *H* included. The general mode of operation in starting a lamp with this circuit arrangement is that, when the switch *E* is closed to turn on the lamp the switch device *H* permits flow of current through the circuit including the cathode filaments *B*, connected in series therein for a length of time sufficient to preheat the cathodes to an adequate emissive temperature to support a discharge between them, and then suddenly breaks the series connection between filaments *B* so that the resulting transient voltage surge or kick produced by the inductance *D* on breaking of the filament circuit is impressed across the space between the cathodes *B* to initiate a discharge between them and start the lamp. The switch *H* shown in the drawing comprises a hermetically sealed alkali-containing glass envelope *J* having a re-entrant stem *K*, through which current leading-in wires *L* and *M* are hermetically fused or welded. The stem is provided with an exhaust tube *N* through which the envelope *J* is exhausted of air and filled with the desired ionisable gaseous atmosphere during the manufacture of the switch. The inner end *O* of wire *M* and the inner end *P* of wire *L* are both of nickel or nickel-iron alloy and the thermally responsive electrode *R* is welded to wire end *O* which serves as its support. The electrode is bent over in a U shape, as shown, so that the free end is located between support *O* and wire end *P* which serves as an electrode. A refractory metal contact *S*, such as a rod of molybdenum, is welded to the electrode *R* adjacent or at the free end and on the surface facing the electrode *P*, which also serves as a contact of the switch. The upper portion of electrode *R* is closer than the contact *S* to the electrode *P* to eliminate the effects of ambient temperature changes on the breakdown voltage of the switch over a predetermined temperature range. The envelope *J* has an ionisable gaseous atmosphere in it for conducting current between the switch electrodes *P* and *R*.—*June* 1, 1955.

GAS PLANTS

733,149. July 25, 1951.—THE MANUFACTURE OF WATER GAS, Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1. (*Inventors: Edward John Challis and Thomas James Perrett Pearce.*)

The invention relates to the manufacture of water gas, particularly to the manufacture of water gas from coal, especially for subsequent use as a synthesis gas (for example, the synthesis of ammonia, methanol or petrol). In the drawing *A* is the blow vessel and *B* the make vessel. Particulate carbonisable carbonaceous material is introduced into make vessel *B* at *C*, and steam, when desired with the addition of air or oxygen, is introduced into make vessel *B* at *D* after having been preheated to, say, 450 deg. Cent. The rate of introduction of this steam and addition is so adjusted that the burden in make vessel *B* is



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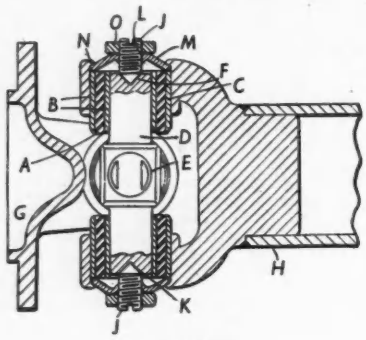
kept in the form of a fluidised bed having, when desired, a disturbed surface similar to that of a boiling liquid. A bed of fluidised particulate solid in this condition is referred to as a boiling bed. The carbonaceous material is circulated through pipeline *E* from make vessel *B* into blow vessel *A*. Here it undergoes partial combustion in a free oxygen-containing gas, such as air, which is blown in at *F* after having been preheated to, say, 450 deg. Cent. The rate of introduction of this free oxygen-containing gas is so adjusted that the burden in blow vessel *A* forms an entrained stream filling the whole blow vessel without any boundary surface between the burden and the space above it being discernible. By the combustion referred to, the burden is heated to a high temperature, say, to 1030 deg. Cent.; it is then recirculated through line *G* to the make vessel *B*, after having been freed of blow gas in a disengagement space *H*. In vessel *B* a temperature of the order of 1000 deg. Cent. is maintained. The gases having passed through the burdens in blow vessel *A* and make vessel *B* pass through the appropriate burdens of cyclones *J*, *K*, *L*, and *M*, where they are freed from most of their dust content, this dust being returned into make vessel *B* by lines *N* and *O*. At *P* and *R* waste heat boilers are shown which were interposed to utilise the waste heat of the gases. The blow gas emerging from cyclone *M* is released into the atmosphere at *S*, while the water gas leaving cyclone *K* is freed from any residual dust in washer *T* and then taken to storage or use at *U*. The composition of the water gas produced in a typical operation as outlined, with steam only, blown into the make vessel *B*, and with the temperature in this make vessel maintained at 950 deg. Cent., was as follows:—CO_2, 12·5 per cent by volume; unsaturates, nil; CO, 30·9 per cent by volume; H_2, 47·1 per cent by volume; saturates, 1·7 per cent by volume; and N_2, 7·8 per cent by volume.—*July* 6, 1955.

POWER TRANSMISSION

732,999. December 15, 1952.—SHAFT COUPLINGS, Joseph Ralph Holland, "Avondale," Newark Road, North Hykeham, Lincoln.

The invention relates to shaft couplings in which the two shafts to be coupled are formed with forked ends having trunnion mountings interconnected by a spider element. Shaft couplings of this kind are the subject of the prior application No. 694,437, which is concerned with an improved construction of flexible connection between the arms of the spider element and the forked ends of the driving and driven shafts. The invention is illustrated in the accompanying drawing. The joint coupling comprises a resilient bush *A*, which in practice may consist of a rubber annulus bonded to metal sleeves *B*,

the outer sleeve being a press fit in a metal cup or other housing *C* carried in a drilling in each pair of forks on the shaft ends. The inner sleeve of each bush *A* encircles the associated arm *D* of the spider *E*, in the ends of each of which are formed circumferential guide slots *F*, the slots being machined to a common centre coincident with the centre of the



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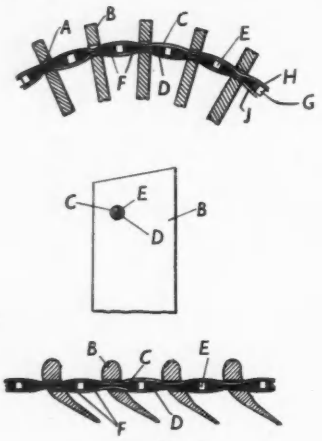
spider block. The locating elements, by which the spider arms *D* are located with respect to the forked ends of the shafts *G* and *H*, take the form, according to the invention, of a pin or stud *J* which may be formed integrally with the metal cup *C*. The end of the stud has a taper *K* to fit the cross-section of the circumferential slot *F*. In the arrangement shown provision is made for radial adjustment of the studs *J*, which for this purpose are screw threaded and are adjustable by screwing in a threaded opening *L* in a cover plate *M*. The cover plates *M* are a press fit in the drillings in the forks and are held in position against a shoulder *N* by the resilient bush, which is a press fit ; *O* is a locknut. While a stud having a taper end is shown, it is obvious that use could be made of a stud which is straight sided or has a round end.—*July* 6, 1955.

STEAM AND GAS TURBINES

732,622. July 22, 1953.—OSCILLATION DAMPERS FOR THE BLADES OF STEAM AND GAS TURBINES AND AXIAL FLOW COMPRESSORS, Aktiengesellschaft Brown, Boveri et Cie., Baden, Switzerland.

The invention consists in oscillation damping devices in the form of loose damping wires divided along their length and located in holes in the blades, the blade oscillations being damped by friction, in which devices, between each two blades and at the ends of the wires, wedge pieces are inserted between the divided wires and fixed in such a way that the wires are forced apart in the plane of separation and closely abut in the blade holes. In the drawing *A* indicates holes in blades *B*. In principle the oscillation damping devices as a whole may have any cross-sectional form and be divided along their length into several wires ; it is, however, an advantage to use two semi-circular wires *C* and *D*, which are inserted



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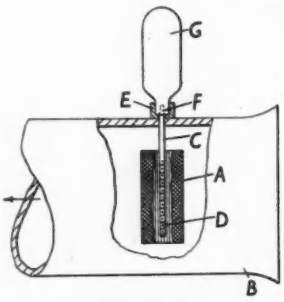
in circular holes which for manufacturing reasons must have a somewhat larger diameter than the wire. The two semi-circular wires thus have a certain amount of play inside the holes. Wedge pieces *E* are then inserted between each two blades, these wedges being located between the divided wires and secured to the latter either mechanically or by soldering at *F*. A wedge piece *G* is also inserted in a similar manner between the ends *H* and *J* of the wires. The oscillation damping device shown is so arranged that its plane of separation with the inserted wedges lies on a cylindrical surface. The flat side of the two semi-circular wires with the inserted wedges can, however, also lie in a plane perpendicular to the axis of the machine, as shown in the lower view, or on a frustro-conical surface, as shown in the centre view, or the plane of separation can be twisted. The oscillation damping devices possess the advantage that they fit closely in the holes of the blades which support them and thus ensure reliable damping of any blade oscillations which occur. Since they are not soldered to the blades and the latter are not or only slightly heated when the wedges are soldered in position, the blades are not affected metallurgically and not weakened in a detrimental manner. This subject is also covered in specification No. 587,588.—*June* 29, 1955.

INTERNAL COMBUSTION ENGINES

732,946. June 29, 1953.—THE STARTING OF DIESEL ENGINES, Inertia Starter Developments, Ltd., 6, Bishopsgate, London, E.C.2. (*Inventor : Ludomir Danilewicz.*)

According to the invention, a porous body is mounted in the induction manifold of a diesel engine and can be wetted with an ignition liquid when desired, immediately before starting. In the arrangement shown in the drawing the porous body is in the



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form of a hollow cylinder of coiled fine mesh wire gauze *A* and is placed inside the induction manifold *B* of an engine. The hollow cylinder is mounted at one end of a coaxial pipe *C* formed with perforations *D* within the cylinder. The pipe extends through the manifold wall to a cap fitting *E*, in which is mounted an upstanding hollow needle *F* for perforating a metal capsule *G* containing ether under pressure. The needle is the sharpened end of pipe *C*. The capsule *G* is perforated simply by thrusting it into the fitting *E*.—*June* 29, 1955.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

THERMOPLASTIC FLOORING TILES

No. 2592 : 1955. Price 2s. 6d.—The tiles specified are composed of a thoroughly blended composition of mineral asphalt, of thermoplastic resins, or of the solid or semi-solid products resulting from the distillation of oil or coal. Asbestos fibres and inert materials are used as fillers or pigments. Requirements for flexible or semi-flexible tiles made from vinyl chloride polymer and co-polymers or other polymeric compositions are not included. B.S. 2592 specifies requirements for materials, dimensions, colour, quality and mechanical tests. The tiles are for use on rigid sub-floors (such as smooth finished concrete), on suitably prepared wood floors, or on other types of structurally sound floor.

WROUGHT ALUMINIUM FOR ELECTRICAL PURPOSES—WIRE

No. 2627 : 1955. Price 2s. 6d.—This new British Standard has been prepared because of the increasing use of aluminium for electrical conductors of many kinds. It refers only to wire used for electrical conductors, such as overhead transmission lines, insulated cables, or windings for rotating machinery or transformers and it is suitable for controlling the quality of wire supplied for electrical components made to other British Standards, such as B.S. 215, "Hard-Drawn Aluminium and Steel-Cored Aluminium Conductors," and B.S. E21, "Electric Cables for Aircraft." Wire for general engineering and other purposes is specified in B.S. 1473, "Rivet, Bolt and Screw Stock for Forging," and B.S. 1475, "Wire," which form part of a comprehensive series of standards for wrought aluminium and aluminium alloys for general engineering purposes (B.S. 1470–77), which are at present under revision. B.S. 2627 is the first of a similar series of standards for wrought aluminium and aluminium alloys for electrical purposes. The system of nomenclature adopted in this standard is cognate with that employed in the general engineering series.

CABLE SEALING BOXES FOR OIL-IMMERSED TRANSFORMERS. PART 1 : BOXES FOR VOLTAGES UP TO AND INCLUDING 11kV

No. 2562. Part 1 : 1955. Price 7s. 6d.—This new British Standard deals with a range of cable sealing boxes of the kind in which the cores of the cables end, and are connected to terminals, within the box itself. The standard was prepared primarily for lead-covered cables and account has been taken of the use of cables with an aluminium sheath. The boxes are classified according to voltage, current rating, number of poles, and the number and size of cables and cable glands. Standard dimensions are given for a range of boxes which are for use indoors or outdoors and also for certain components of the boxes. In addition to seven tables, eighteen figures are included which illustrate the method of classification. The figures also give standardised dimensions of the boxes in each class. Although the standard does not purport to specify complete details of design and construction, some observations on this aspect are included for guidance. It is intended to issue in due course a second part covering boxes for voltages in excess of 11kV.

Catalogues

METAL SECTIONS, Ltd., Oldbury, Birmingham.—Copy of the Metsec building catalogue.

JUNG SCHLEIFMASCHINEN, H. GAUB, Berlin.—Brochures on automatic and internal grinding machines.

STONE-WALLWORK, Ltd., 32, Victoria Street, London, S.W.1.—Two leaflets on P.I.V. compound gears.

HOLOPHANE, Ltd., Elverton Street, Westminster, London, S.W.1.—Catalogue of commercial lighting.

GEORGE KENT, Ltd., Luton, Bedfordshire.—Publication 953/255, describing Kent rotary piston water meters.

J. COLLIS AND SONS, Ltd., Regent Square, Gray's Inn Road, London, W.C.1.—Brochure describing the Collis truck.

DOMINION ENGINEERING COMPANY, Ltd., Winnipeg, Canada.—Bulletin No. 214–20 on Dominion spherical valves.

THOMAS ROBINSON AND SON, Ltd., Rochdale.—Brochure series 29A, describing modern woodworking machinery.

WILKINSON RUBBER LINATEX, Ltd., Camberley, Surrey.—Publication on Linatex abrasion and corrosion-resistant linings.

WELLINGTON TUBE WORKS, Ltd., Great Bridge, Tipton, Staffs.—Publication No. 155, dealing with tubular heat exchangers.

THE MIDLAND DYNAMO COMPANY, Ltd., 64, Belgrave Gate, Leicester.—Leaflet on "Quickway" armature winding machines.

ARCOLECTRIC (SWITCHES), Ltd., Central Avenue, West Molesey, Surrey.—Catalogue No. 129, "Switches and Signal Lamps."

W. C. HOLMES AND CO., Ltd., Turnbridge, Huddersfield.—Publication No. 52, giving details of the redesigned Holmes-Western valve.

ALLWEATHER PAINTS, Ltd., 36, Great Queen Street, London, W.C.2.—Brochure describing the uses of Pitan chlorinated rubber paints.

GENERAL REFRACTORIES, Ltd., Genefax House, Sheffield, 10.—Publication entitled "An Outstanding Achievement in Silica Refractories."

BOWDEN (ENGINEERS), Ltd., Victoria Road, Willesden Junction, London, N.W.10.—Brochure illustrating the Bowden range of flexible pipe control units.

F. J. EDWARDS, Ltd., 359–361, Euston Road, London, N.W.1.—Volume of technical literature covering the complete range of Besco sheet metal working machinery.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 9604, laboratory machinery, and Publication 6507 on pneumatic dust collecting and conveying.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., 51/53, Hatton Garden, London, E.C.1.—Catalogue C, illustrating and giving details of all types of paper-insulated cables ; Booklet No. 508, dealing with 33kV solid type cables.

NEWALLS INSULATION COMPANY, Ltd., Washington, Co. Durham.—Publication No. H.1.4.T.R.3.55, on heat insulation. Publication No. S.I.1.T.R.4.55, noise and acoustic treatment reduction. Publication No. S.L.A.2. T.R. 1.55.M., on sprayed "Limpet" asbestos.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Mon., Aug. 8th, to Sat., Aug. 20th.—Exhibition on the Peaceful Uses of Atomic Energy, Geneva.